THE FIRST ANNUAL AWARD FOR EXCELLENCE IN TEACHING. A STUDY OF PROCEDURE AND ANALYSIS OF DATA

by

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United States
Naval Postgraduate School

THESIS

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ABSTRACT

A study and documentation of the first annual Award for Excellence in Teaching is made. A brief background for the Award is presented, including the formation of a committee designated to choose objectively a worthy recipient. The problems encountered by the committee in designing a successful ballot and the statistical methods used in selecting the recipient are of major concern and are treated in detail. Basic response statistics are published accompanied by a data summary. Special studies including score analysis, weight component determination, and teacher elimination by dominance techniques are presented. To better understand the various population strata, several correlation studies are made.

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ACKNOWLEDGEMENT

The author is greatly indebted to the Selection Committee for its valuable assistance in formalizing the special concept of dominance herein, and in particular to Professor Robert R. Read for the many hours of professional help which made this work possible.

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I. BACKGROUND

In May, 1969, the Superintendent of the Naval Postgraduate School, Radm. Robert W. McNitt, USN, established the Outstanding Teaching Award to be conferred upon a member of the Faculty of the Naval Postgraduate School annually at the time of the June Graduation Exercises. It was intended that the first conferral of the Award be made in June, 1970.

Selection of the recipient was to be accomplished according to certain guideline procedures prepared by an Ad Hoc Committee appointed by the Academic Dean. The Ad Hoc Committee consisted of Professors Gaskell (Chairman), Handler, O'Toole, and Strum. In addition to basic guidelines, the Ad Hoc Committee made provisions for the establishment of a permanent selection committee to choose the recipient annually, thus insuring a growing efficiency and refinement of the process. Membership on the committee would be for two year pereiods, with exception of the first committee, and each year half of the committee would step down, thus combining past knowledge and familiarity of the problem with new talents and ideas.

The first selection committee finally evolved to the membership of Professors Gawain (Chairman), Kovach (Vice-Chairman and Secretary), Boggess, Nunn, Read, Strum, and Woehler. The initial efforts of the selection committee were towards setting a general tone for the award itself. It was felt that a small group of the Faculty members could

be identified who merit consideration for the Award, but that a selection from among this group of one individual, however deserving he may be, was not likely to preempt all other candidates in every respect. Therefore, it was felt that the selection of one individual could properly be regarded as a representative and symbol of the excellence of his peers.

In attempting to fulfill its assigned responsibilities, the committee tried to formulate an adequate philosophical outlook concerning the nature of excellence in teaching and how it could be reliably identified and evaluated. After much research, both outside and inside the committee, the Committee reached the following general conclusions:

(a) There did not exist any objective and generally accepted method for quantitatively measuring excellence in teaching.

(b) Experience at the Naval Postgraduate School and elsewhere indicated that mature students and other qualified observers do on the whole show a reasonable degree of consistency in judgments of persons engaged in teaching.

(c) The Committee could properly designate the recipient on the basis of the representative judgments of persons qualified to hold opinions.

(d) It appeared that a polling procedure could be used to achieve this objective.

(e) Well developed statistical techniques were available which could be used to guide the quantitative interpretation of the poll.

The Committee next desired to put down on paper some statement that approached the correct interpretation of the phrase "excellence in teaching." This phrase was to refer

to that complex of personal and professional qualities and actions on the part of the teacher which:

(a) Make themselves felt primarily at the interface of personal contact between student and teacher.

(b) Help transmute the student's encounters with his subject matter into insight, enlightenment and love of learning.

(c) Elicit from the student responses in thought, feeling, and action which enhance his capacity for self education.

(d) Manifest themselves in an effective individual style which authentically reflects the teacher's own unique personality, experience, character, and convictions.

With reference to the actual polling procedure to be followed, the Committee proposed the following specific points:

(a) The following individuals would be eligible to participate: all students, all Faculty members,[1] all Curricular and Assistant Curricular Officers, and a representative group of recent alumni. The exact composition of this group to be specified later.

(b) Participation in the poll would be entirely voluntary.

(c) The polling would be by secret ballot.

(d) Stringent security measures would be taken to guarantee that the poll could not be misused in any fashion which would be detrimental to the status or interests of any individual Faculty member.

(e) In order to be eligible to participate in the poll, an individual must have indicated that he considers himself to be reasonably well acquainted with the actual teaching performance of five or more Faculty members.

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[1]Department Chairmen and members of the Selection Committee were declared ineligible to receive the award. They were not excluded from the poll, however.

(f) Participants would be cautioned to avoid nominating teachers on the basis of mere personality or popularity. No attempt would be made to provide a definite check list of required qualities for excellence in teaching. The Committee's guidelines in this area were to be optional.

(g) Data obtained in the poll would be analyzed objectively, using appropriate statistical methods which would take into account all relevant factors.

II. CONDUCT OF POLL

A. BALLOT FORMAT

After setting the philosophical tone of the award, the selection committee directed its attention to the appropriate ballot format. It was decided that the ballot itself would consist of three basic parts. The first, a statistical information section, was designed to obtain data to help understand various characteristics of the polled population. The second part consisted of a listing of the faculty eligible for the teaching award, and the third part was to invite a supporting remark for the voter's primary nomination. A sample ballot is included in Appendix A.

Information requested in Part I of the ballot provided data for statistical procedures to be used in an effort to gain a better understanding of the voter population. It was desired to know the Voter Category of each individual being polled. Consequently, the four categories consisting of Student, Faculty, Alumnus, and Curricular Officer were used. These four categories were desired to be mutually exclusive and totally exhaustive.

If the voter were military, additional information as to Rank and Branch of Service was requested. If the voter were a student, his curricular area would be of interest, and if he were a member of the Faculty, his Academic Rank and Department would supply pertinent statistical information.

The second part of the ballot displayed a listing of the eligible faculty, or those faculty who had engaged in teaching during the current academic year, except department chairmen and members of the selection committee.

An effective method of listing the eligible faculty was desired. The committee, realizing that most students (and consequently, alumnus) and faculty identified a teacher with an academic department, decided to have thirteen major heads corresponding to the thirteen departments. Within each department, the teachers were listed alphabetically. Hopefully, this method would facilitate finding a specified group of teachers with which the voter would be acquainted.

Part III was included to obtain subjective information supporting the primary nomination of the voter concerned. Since this information was optional, the committee decided not to fix any policies regarding its usage in the selection process. But, such information would provide an inlet for subjectivity in the process which the committee felt might be necessary and appropriate.

To accompany the actual ballot, a page of publicity and instruction was felt necessary. The committee decided that such a page should consist basically of two parts: a short statement of the background of the award and a statement of the balloting procedure. Therefore, a short summary of the philosophical thinking of the committee was included to introduce the subject of "teaching excellence" to the voter.

The balloting procedure consisted of five steps; three of which require explanation. Step 1 requested the voter to encircle the teacher number of all the faculty with which he was "sufficiently acquainted to make a judgment." It was emphasized that the voter encircle all those that fell into the above category in order to establish a basis of comparison.

In Step 2, the voter was directed to select one (1) to three (3) nominees and to rank them in order of preference. The committee decided that a scoring system would be based on points awarded for first, second, and third place votes only.

Finally, Step 3 invited the voter to utilize Part III of the actual ballot by giving supporting remarks for his first place nomination. This step was to be optional.

B. VERIFICATION OF DATA

The listing of teachers described above included a four digit number identifying each teacher. These numbers served a two-fold purpose. They were used in the processes of data collection and statistical manipulation; and secondly, the numbers served as a verification process by which the IBM data cards could be checked for key punch errors.

Each teacher number was constructed in the following manner. The first three digits formed a number that increased in numerical order for each teacher going down the listing, starting with number 101. Therefore, the second teacher down the list had the first three digits 102, the third teacher,

103, etc. Let $\bar{N}$ be a vector whose elements consist of these first three digits. The fourth digit of the teacher number was obtained by using the units digit of the inner product $\bar{N} \cdot \bar{S}'$, where $\bar{S}$ was an arbitrary weight vector chosen to (3 5 1). As an example, for teacher 101, the fourth digit would be the units digit of

$$(1\ 0\ 1)\begin{pmatrix}3\\5\\1\end{pmatrix} \quad \text{or} \quad 4 .$$

Thus, his full number would be 1014. This procedure rendered itself to computer verification of all key punched data cards. Other verification techniques appropriate to the programming language (COBOL) were used for the statistical information provided in Part I of the ballot.

C. RESPONSE ANOMALIES

Although much effort was put into the design of the ballot format, it was anticipated that not every point would be clear to the individual voter. An analysis of the returned ballots proved this conjecture to be true.

Multiple answers in any one of the informational areas of Part I would cause problems for proper statistical analysis. It was found that although the Voter Category information was totally exhaustive, it was not mutually exclusive, especially among the Alumnus and Curricular Officer categories. Consequently, revision of the collection process for this information is required. Confusion became apparent as to which

Military Rank category a foreign officer belonged. Proper corresponding ranks should be outlined in any future polling of this sort. It was discovered that the options under Curricular Area were not mutually exclusive. An attempt was made to correct the above errors by examining the ballot concerned. Such errors were not used as a basis for ballot rejection.

The most common cause for rejection of a ballot was the requirement that the voter be acquainted with at least five faculty members listed as eligible teachers. This requirement was established since the committee felt that each voter should be acquainted with at least a certain minimum number of teachers in order to make a meaningful comparison. The number five seemed reasonable. It would exclude most first quarter students but very few of the others. This rejection principal, although resulting in a "void" ballot, could not be considered an error on the part of the voter and consequently, was not a function of ballot format. The requirement was not publicized on the ballot, however.

Two other major causes of rejection were late ballots and multiple selections for first, second, and third place votes. After a certain date, late ballots could no longer be considered in the selection process and therefore became void. Also, there were many ballots returned blank because of the lack of forwarding addresses. A substantial number of voters interpreted the procedure instructions to mean that multiple choices for first, second, or third place nominations were

acceptable; thus, future clarification of this mis-interpretation is needed. Table I summarizes the void ballots. Late ballots consisted of alumni ballots received in the mail too late for processing.

TABLE I

Void Ballot Summary

A.	Late ballots	
	Valid	20
	Void	2
	Blank (Returned to sender)	37
B.	Pop. < 5	171
C.	Multiple Nominations	24

There were 1023 valid ballots used in the selection process. The results of the poll would become more representative and the statistical findings more meaningful with a reduction in the number of void ballots.

III. POPULATION CHARACTERISTICS

A. RESPONSE STATISTICS

One of the most interesting and important population characteristics concerned the degree of voluntary participation the Teaching Award could arouse. In order to ascertain the level of interest reached by the voter population, basic response statistics were compiled. These statistics were based only on valid ballots; ballots that were free from the errors listed above and had $M_i \geq 5$, where M_i was the size of the population of teachers identified by the i^{th} voter.

Response by Voter Category gave general response statistics. Table II gives a two-way classification of the Student ballots received. Each interior entry in the table represents the number of ballots received from the i^{th} Military Rank of the j^{th} Curricular Area. The top row is a count of those Student ballots listing only a Curricular Area. Similarly, the left-hand column represents those ballots known only by Military Rank. The bottom row gives the percentage response within each Curricular Area. In review, from the 1485 students at the Postgraduate School when the poll was conducted, 728 responded in an acceptable manner, yielding an overall response of 49%.

Table III shows a similar response for the Alumnus ballots. Each interior entry represents the number of ballots received from the i^{th} Military Ranking of the j^{th} Curricular Area.

TABLE II

Response by Student Voter Category

Student Curricular Area

Military Rank	Q \ P	Ops Ana	Aer Eng	Ele Eng	Ord Eng	Nav Eng	Eng Sci	Man CSc	Env Sci	Bac Pgm	Def Man	
		4	1	9	9	4	8	3	0	2	0	R
01	0	9	6	7	5	9	5	14	2	4	0	61
02	1	0	1	3	1	3	1	1	0	0	0	11
03	0	54	25	57	25	17	44	48	1	30	0	301
04	2	41	10	27	23	15	39	48	0	49	1	265
05	0	6	0	1	1	1	1	22	0	21	1	54
06	1	0	0	1	0	3	0	0	0	1	0	6
S/T		114/256	43/68	105/153	64/120	52/79	98/119	136/319	3/80	107/291	2/36	
U		45	63	69	53	66	82	43	4	37	6	

P Students known in Curricular Area only

Q Students known in Military Rank only

R Student Ballot Distribution by Rank

$\frac{S}{T}$ $\frac{\text{Total Response by Curricular Area}}{\text{Total Enrollment of Each Area}}$

U Percentage Response by Curricular Area

TABLE III

Response by Alumnus Voter Category

Student Curricular Area

Military Rank	B \ A	Ops Ana	Aer Eng	Ele Eng	Ord Eng	Nav Eng	Eng Sci	Man CSc	Env Sci	Bac Pgm	Def Man	C
	1	1	0	0	0	1	1	0	0	0	
01	0	1	0	1	0	0	0	2	0	1	0	5
02	0	0	0	0	0	0	0	0	0	0	0	0
03	1	1	0	4	3	1	3	6	1	1	0	21
04	1	14	12	11	19	12	21	16	1	20	1	128
05	1	8	2	2	0	0	5	12	0	15	1	46
06	0	0	0	1	0	0	0	1	0	0	0	2
D		25	15	19	22	13	30	38	2	37	2	

A Alumnus known by Curricular Area only

B Alumnus known by Military Rank only

C Alumnus ballot distribution by Rank

D Total response by Curricular Area

The top row and left-hand column have the same meaning as above. The bottom row is the total response from the j^{th} Curricular Area. Since there were two ballots that did not indicate a Military Rank or Curricular Area, the total Alumnus response was 208 ballots. There were 530 ballots mailed, yielding a return of 39%.

It should be noted that the polling of Alumni poses some difficult problems. They must be contacted by mail, and hence a listing of current addresses is needed. This need can be served, to a large part, by the use of Reference 2 and the associated data tape which contains a list of previous graduates. There are shortcomings, however:

(a) The tape contains listings of former officer students restricted to Naval personnel who are still active. Moreover, the tape requires periodic updating to keep the addresses reasonably current.

(b) The addresses contained on the tape are coded. These must be translated into addresses that are usable in the mail system. Such can be accomplished with the aid of References 7 and 8, but experienced personnel are required to do this.

Experience suggests that at least two months lead time are needed to update the tape, and at least one month to translate the addresses.

Table IV shows the response of the Faculty ballots. Each interior entry represents the ratio

$$\frac{\text{\# of ballots in the } i,j^{th} \text{ category}}{\text{total \# possible}} ;$$

TABLE IV

Response by Faculty Voter Category

		Academic Department												
	E / F	Aer Eng	Avi Sty	Man CSc	Ele Eng	Gov Hum	Ma	Mec Eng	Mr	Oc	Ops Ana	Phy	Nav Sys	Mat Che
		1	1	0	0	0	0	0	0	0	0	0	0	0
Aca. Rank	Pro 0	2/7	0/0	2/4	3/20	0/3	3/13	0/8	0/3	2/4	0/4	8/14	0/4	3/10
	Acc 0	2/7	1/2	2/8	6/19	0/3	3/6	1/2	1/4	1/2	2/12	2/13	0/3	0/3
	Ass 0	1/3	0/1	2/6	0/4	0/4	4/5	1/6	3/3	2/6	4/16	2/5	0/1	0/1
	Ins 0	1/2	1/2	0/8	1/3	0/2	2/12	0/1	0/3	0/2	0/4	0/3	0/8	0/0
	G	7/19	3/5	6/26	10/46	0/12	12/36	2/17	4/13	5/14	6/36	12/35	0/16	3/14
	H	37	60	23	22	0	33	12	31	36	17	34	0	21

E Faculty known in Academic Department only
F Faculty known in Academic Rank only
G Total response by Academic Department
H Percentage response of Academic Department

thus, it is the fractional response by Academic Rank from each Department. The top row and left-hand column again have the same interpretation as above. The bottom row gives the percentage response within each Academic Department. There were four (4) ballots received that did not list an Academic Rank or Department; thus, the total response from the Faculty was 74 ballots out of 289. The overall response of the Faculty was 25.6%.

Of the ten Curricular Offices, a total of three ballots was received.

Of the 1023 valid ballots used by the selection committee, the Voter Categories represented the following percentages:

Curricular Office	.3%
Alumnus	20.3%
Faculty	7.2%
Student	71.1%
Unknown	1.1%

B. DISTRIBUTION ANALYSIS OF N_k AND M_i

In a further attempt to better understand the voter population, two characteristics were of interest. Associated with each ballot was the number of teachers identified by that ballot, and associated with each teacher was the number of voters identifying him. To gain this understanding, analyses on these two characteristics were made.

Figure 1 is a histogram of N_k, the number of voters identifying the k^{th} teacher. The average value of N_k was 64.5, with a standard deviation of 49.4.

Figure 2 shows a frequency distribution of M_i for the Faculty voters only; where M_i is the number of teachers identified by the ith voter. Similarly, Figure 3 is a distribution of M_i for all the voters.

It is interesting to note the high average of the Faculty ballots, 32.1, when compared to that of 15.5 for all the ballots. Undoubtedly the faculty's criteria for "being acquainted" with a teacher are different from those of the students.

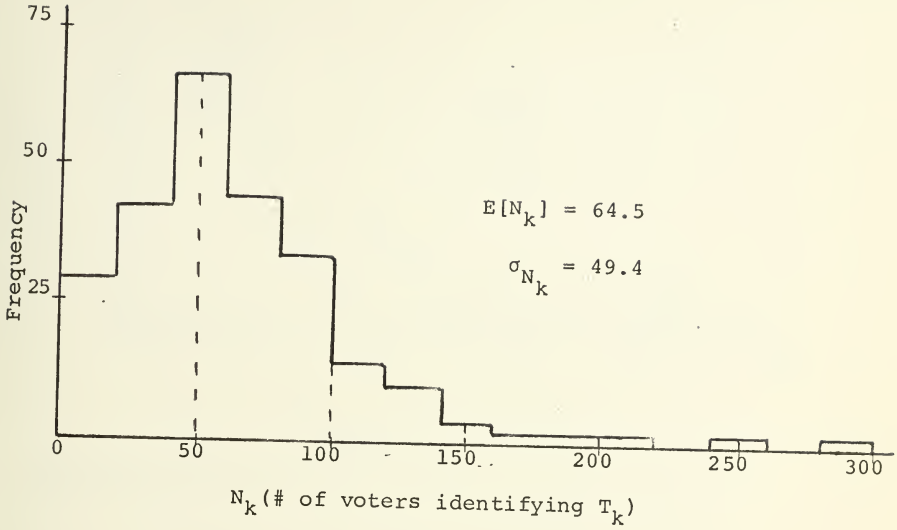

FIGURE 1

Histogram of N_k

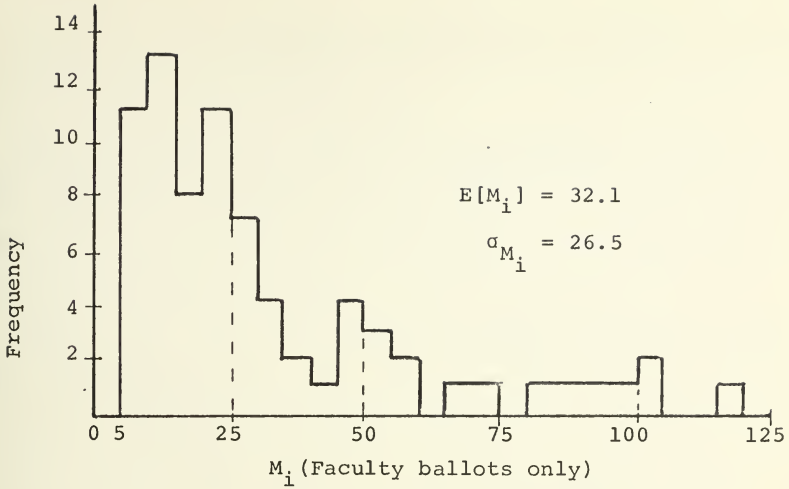

FIGURE 2

Frequency Distribution of M_i For Faculty Ballots

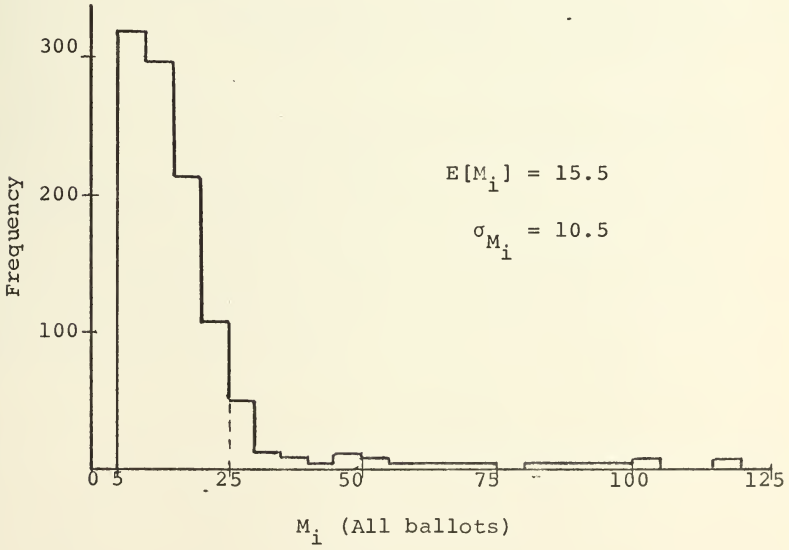

FIGURE 3

Frequency Distribution of M_i for All Ballots

C. DISTRIBUTION ANALYSIS OF D_k

Since an option was left to the voter whether or not to add a supporting statement, it was desired to know how the voter population reacted. The following analysis was made with this objective in mind.

Define X_{1k} to be the number of ballots awarding a first place nomination to T_k, and D_k to be the number of these that add a supporting statement. Figure 4 is a scatter diagram of P_k vs. X_{1k}, $X_{1k} \geq 5$, where $P_k = D_k/X_{1k}$, the proportion of X_{1k} that voluntarily added a comment.

To estimate the probability that a supporting statement was made, a "pooled" value of P_k resulted in

$$p = \sum D_k / \sum X_{1k} = .341$$

Examining Figure 4, it would be difficult to conclude that P_k was in any sense approximately constant, or that any correlation coefficient other than zero would fit the observed data. It was concluded that the probability of receiving a supporting statement was independent of the number of first place votes.

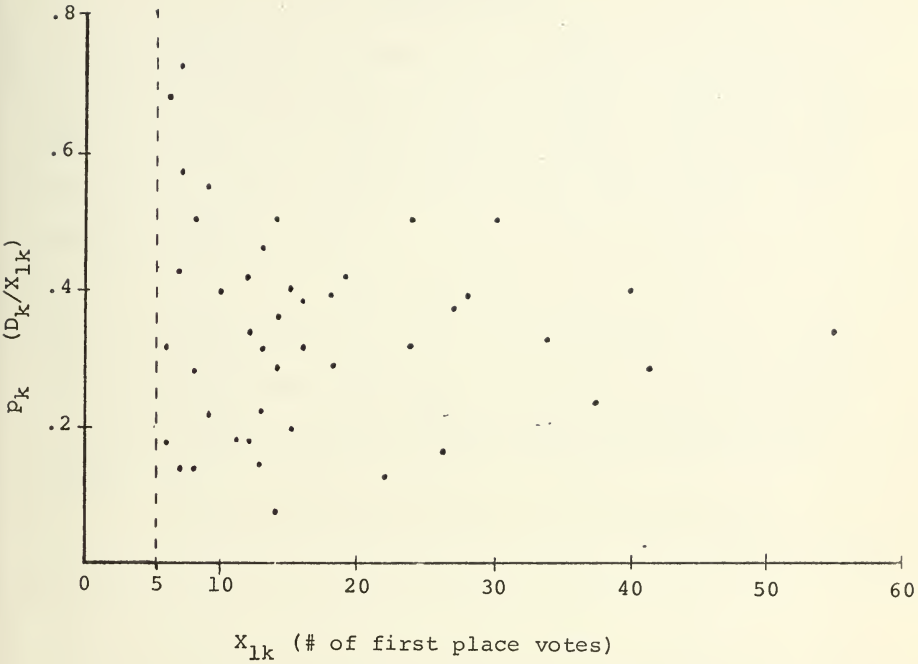

FIGURE 4

Scatter Diagram of p_k vs. X_{1k}

IV. DATA SUMMARY

The following is a summary of the data utilized by the committee in the selection process. Each row represents the pertinent data for a single teacher, and is ranked from top to bottom in order of decreasing score, where teacher k's score is defined to be

$$S_k = V_k \cdot \bar{W} ,$$

and $\bar{W}$ is the weighting vector analyzed below. N_k and D_k are as defined above, and X_{ik}, $i = 1,2,3$ are the number of first, second, and third place nominations received by teacher k .

k	S_k	N_k	D_k	X_{1k}	X_{2k}	X_{3k}
1	2.36207	58	11	28	10	5
2	2.35593	59	15	30	8	3
3	2.33019	106	17	54	13	5
4	2.21154	52	8	24	6	7
5	2.01099	91	16	40	8	7
6	1.78082	73	3	22	17	8
7	1.74074	27	4	7	8	3
8	1.73333	120	11	41	15	14
9	1.71429	42	7	14	7	2
10	1.68539	89	9	25	21	8
11	1.61842	76	8	19	19	9
12	1.51852	81	12	24	11	5
13	1.41538	130	11	34	18	12
14	1.35616	73	7	18	10	7
15	1.29927	137	10	27	28	14
16	1.28205	39	0	9	6	2
17	1.28000	50	2	13	4	4
18	1.27778	18	0	4	3	1
19	1.24590	61	1	14	7	6
20	1.18868	53	5	9	8	11
21	1.18182	44	4	8	9	2
22	1.13115	61	5	12	8	5
23	1.02913	103	6	15	19	8
24	1.00000	51	1	7	9	5
25	0.97826	92	5	18	7	4
26	0.97826	92	3	15	13	4
27	0.96629	89	5	14	13	4
28	0.96262	107	6	16	14	11
29	0.94444	36	2	5	6	2
30	0.90625	64	4	7	11	8
31	0.88889	45	3	7	4	4
32	0.87850	107	2	12	14	18
33	0.86111	72	2	9	11	4
34	0.85714	7	1	1	1	0
35	0.85000	20	1	3	2	1
36	0.84444	90	4	12	11	6
37	0.82759	58	1	8	5	6
38	0.80000	15	0	2	2	0
39	0.78049	41	2	3	6	8
40	0.77686	121	4	10	22	10
41	0.77273	44	1	8	0	2
42	0.77228	101	4	13	9	8
43	0.76471	17	0	2	2	1
44	0.76000	50	1	7	4	2
45	0.74783	115	5	14	9	12
46	0.72222	144	4	14	13	22
47	0.71698	106	3	13	9	6
48	0.71429	49	3	5	4	7
49	0.68254	63	4	6	8	3
50	0.68212	151	6	14	16	15

k	S_k	N_k	D_k	X_{1k}	X_{2k}	X_{3k}
51	0.66102	59	2	5	6	7
52	0.65000	20	1	2	2	1
53	0.64474	76	5	7	7	7
54	0.59677	124	5	16	4	2
55	0.59494	79	0	4	11	9
56	0.58065	62	2	6	5	2
57	0.57143	28	1	1	2	8
58	0.56364	55	2	4	6	3
59	0.54545	11	0	1	1	0
60	0.53846	52	1	4	4	4
61	0.52830	53	0	3	6	4
62	0.52632	57	3	5	3	4
63	0.52500	40	0	2	5	3
64	0.52174	138	6	13	7	6
65	0.51064	47	0	2	6	4
66	0.51020	49	1	4	4	1
67	0.50000	4	0	0	1	0
68	0.48387	31	0	2	3	1
69	0.46281	121	1	6	11	10
70	0.44872	78	0	5	3	9
71	0.44304	79	2	5	5	5
72	0.43902	41	2	2	4	2
73	0.43396	53	0	4	1	5
74	0.43182	44	0	3	3	1
75	0.42857	28	0	2	2	0
76	0.42857	7	0	0	1	1
77	0.42500	80	0	3	7	8
78	0.41860	43	2	4	1	0
79	0.40909	66	0	1	8	7
80	0.40000	45	0	2	3	4
81	0.39474	38	0	2	3	1
82	0.38983	59	0	4	2	3
83	0.38710	31	0	1	1	6
84	0.38462	52	0	3	2	4
85	0.38194	288	2	11	21	24
86	0.37681	69	0	2	4	10
87	0.37500	88	1	4	2	13
88	0.37255	51	2	2	4	3
89	0.37209	43	1	1	5	2
90	0.37179	78	1	2	6	9
91	0.37037	27	0	2	0	2
92	0.36735	49	2	3	2	2
93	0.36585	82	2	2	6	10
94	0.36000	75	2	3	5	5
95	0.35000	20	1	1	1	1
96	0.34667	75	0	3	3	8
97	0.34167	120	0	1	12	13
98	0.34021	97	1	4	6	5
99	0.33846	65	0	2	5	4
100	0.33333	81	3	5	2	3

k	S_k	N_k	D_k	X_{1k}	X_{2k}	X_{3k}
101	0.31915	47	0	0	5	5
102	0.31818	22	1	1	1	1
103	0.31746	63	1	2	3	6
104	0.30882	68	0	2	2	9
105	0.30263	76	0	2	5	5
106	0.30108	93	0	4	4	4
107	0.30000	50	1	1	4	3
108	0.29670	91	1	4	3	5
109	0.29630	27	0	2	0	0
110	0.28947	38	1	2	1	1
111	0.28704	108	0	2	8	7
112	0.28641	206	1	6	12	11
113	0.28571	49	0	1	3	4
114	0.28571	7	0	0	1	0
115	0.27273	77	0	2	5	3
116	0.26923	182	1	5	8	13
117	0.26772	127	2	6	3	4
118	0.25000	52	0	0	6	1
119	0.24528	53	0	2	1	3
120	0.23958	96	0	3	5	1
121	0.23077	26	0	0	2	2
122	0.23000	100	2	4	2	3
123	0.22951	61	0	1	4	2
124	0.22807	57	0	0	5	3
125	0.22667	75	0	0	6	5
126	0.22667	75	0	0	6	5
127	0.22581	62	1	2	2	2
128	0.20930	43	0	0	3	3
129	0.20755	106	0	2	6	2
130	0.19835	121	0	1	6	8
131	0.19048	21	0	1	0	0
132	0.18750	80	0	1	3	5
133	0.18750	64	0	2	1	2
134	0.18750	32	1	1	0	2
135	0.18421	76	1	2	2	2
136	0.17857	56	1	2	0	2
137	0.17647	51	0	1	2	1
138	0.17500	40	0	1	1	1
139	0.17045	88	1	2	3	1
140	0.17045	88	1	3	1	1
141	0.17021	47	0	1	2	0
142	0.15517	58	0	2	0	1
143	0.15385	65	1	2	1	0
144	0.15385	26	0	0	1	2
145	0.15000	40	0	1	1	0
146	0.14815	27	0	0	2	0
147	0.14706	68	0	1	2	2
148	0.14667	75	0	1	1	5
149	0.14286	28	0	1	0	0
150	0.13889	36	0	0	2	1

k	S_k	N_k	D_k	X_{1k}	X_{2k}	X_{3k}
151	0.13158	38	0	1	0	1
152	0.12791	86	0	1	3	1
153	0.12571	175	2	2	5	4
154	0.12500	40	0	1	0	1
155	0.12281	57	0	1	1	1
156	0.12069	58	0	0	2	3
157	0.11765	51	0	0	1	4
158	0.11702	94	0	1	2	3
159	0.11268	71	0	0	3	2
160	0.11250	80	1	1	2	1
161	0.10870	46	0	0	1	3
162	0.10714	56	0	1	0	2
163	0.10526	95	0	1	2	2
164	0.10000	40	0	1	0	0
165	0.09877	81	1	1	2	0
166	0.09859	71	0	0	2	3
167	0.09615	52	0	0	2	1
168	0.09333	75	0	1	1	1
169	0.09302	43	0	1	0	0
170	0.09195	87	0	0	2	4
171	0.08537	164	0	1	2	6
172	0.08235	85	0	0	2	3
173	0.08125	160	1	1	3	3
174	0.08108	74	0	1	1	0
175	0.07895	190	0	1	5	1
176	0.07813	64	0	1	0	1
177	0.07692	52	0	0	2	0
178	0.07527	93	0	0	3	1
179	0.06818	44	0	0	0	3
180	0.06383	94	0	0	1	4
181	0.06364	110	0	0	2	3
182	0.06061	99	0	1	0	2
183	0.05882	34	0	0	0	2
184	0.05797	69	0	0	1	2
185	0.05714	35	0	0	1	0
186	0.05556	36	0	0	1	0
187	0.05333	75	0	0	1	2
188	0.05263	57	0	0	1	1
189	0.05102	98	1	1	0	1
190	0.04918	61	0	0	0	3
191	0.04717	106	0	0	2	1
192	0.04444	45	0	0	1	0
193	0.04132	242	0	0	3	4
194	0.04000	50	0	0	1	0
195	0.03704	54	0	0	0	2
196	0.03571	28	0	0	0	1
197	0.03509	57	0	0	1	0
198	0.03448	58	0	0	1	0
199	0.03261	92	0	0	0	3
200	0.03125	32	0	0	0	1

k	S_k	N_k	D_k	X_{1k}	X_{2k}	X_{3k}
201	0.02439	82	0	0	1	0
202	0.01600	125	0	0	1	0
203	0.01235	81	0	0	0	1
204	0.01111	90	0	0	0	1
205	0.00746	134	0	0	0	1
206	0.00000	119	0	0	0	0
207	0.00000	96	0	0	0	0
208	0.00000	94	0	0	0	0
209	0.00000	61	0	0	0	0
210	0.00000	60	0	0	0	0
211	0.00000	56	0	0	0	0
212	0.00000	54	0	0	0	0
213	0.00000	53	0	0	0	0
214	0.00000	52	0	0	0	0
215	0.00000	48	0	0	0	0
216	0.00000	47	0	0	0	0
217	0.00000	43	0	0	0	0
218	0.00000	42	0	0	0	0
219	0.00000	41	0	0	0	0
220	0.00000	39	0	0	0	0
221	0.00000	37	0	0	0	0
222	0.00000	33	0	0	0	0
223	0.00000	30	0	0	0	0
224	0.00000	28	0	0	0	0
225	0.00000	28	0	0	0	0
226	0.00000	28	0	0	0	0
227	0.00000	27	0	0	0	0
228	0.00000	26	0	0	0	0
229	0.00000	26	0	0	0	0
230	0.00000	25	0	0	0	0
231	0.00000	25	0	0	0	0
232	0.00000	19	0	0	0	0
233	0.00000	17	0	0	0	0
234	0.00000	15	0	0	0	0
235	0.00000	15	0	0	0	0
236	0.00000	14	0	0	0	0
237	0.00000	13	0	0	0	0
238	0.00000	12	0	0	0	0
239	0.00000	10	0	0	0	0
240	0.00000	7	0	0	0	0
241	0.00000	7	0	0	0	0
242	0.00000	6	0	0	0	0
243	0.00000	4	0	0	0	0
244	0.00000	4	0	0	0	0
245	0.00000	4	0	0	0	0
246	0.00000	3	0	0	0	0
247	0.00000	3	0	0	0	0
248	0.00000	2	0	0	0	0
249	0.00000	1	0	0	0	0

V. SPECIAL ANALYSES

The following special studies were conducted in order to objectively choose a worthy recipient and also to gain knowledge concerning the distribution of positive scores.

A. DOMINANCE CONCEPT AND SCREENING RATIONALE

1. Background

In this section, a concept of dominance is developed and discussed which served as a powerful screening criterion leading to the final selection of the award winner.

Let T_k represent teacher k and N_k represent the number of voters indentifying teacher k on their ballots. Define X_{ik} as above. Now, let $V_{ik} = X_{ik}/N_k$, $i = 1,2,3$ represent the fraction of first, second, and third place votes awarded to T_k from the population that knew him. Therefore, each teacher has a return vector, $V_k = (V_{1k}, V_{2k}, V_{3k})$ which will be used to measure his excellence as a teacher. Table V is a display of V_k for the top 25 teachers.

2. Development

Teacher k's score, S_k , can now be represented by

$$S_k = \sum_{i=1}^{3} w_i V_{ik}$$

$$= w_1 V_{1k} + w_2 V_{2k} + w_3 V_{3k} \qquad (1)$$

TABLE V

Return Vector V_k

k	V_{1k}	V_{2k}	V_{3k}
1	0.48276	0.17241	0.08621
2	0.50847	0.13559	0.05085
3	0.50943	0.12264	0.04717
4	0.46154	0.11538	0.13462
5	0.43956	0.08791	0.07692
6	0.25926	0.29630	0.11111
7	0.30137	0.23288	0.10959
8	0.28090	0.23595	0.08989
9	0.34167	0.12500	0.11667
10	0.33333	0.16667	0.04762
11	0.25000	0.25000	0.11842
12	0.29630	0.13580	0.06173
13	0.26154	0.13846	0.09231
14	0.24658	0.13699	0.09589
15	0.19708	0.20438	0.10219
16	0.22222	0.16667	0.05556
17	0.23077	0.15385	0.05128
18	0.26000	0.08000	0.08000
19	0.16981	0.15094	0.20755
20	0.22951	0.11475	0.09836
21	0.18182	0.20455	0.04545
22	0.19672	0.13115	0.08197
23	0.14563	0.18447	0.07767
24	0.13725	0.17647	0.09804
25	0.19565	0.07609	0.04348

where $\overline{W} = (w_1, w_2, w_3)$ is a weighting vector to be specified later.

In general, $\overline{W}$ is subject to the constraint that

$$w_1 > w_2 > w_3 > 0 \ . \qquad (2)$$

It would be non-sensical to give more weight to either a second or third place vote than to a first place vote. Consequently, from (2) above,

$$0 < w_2/w_1 < 1$$
$$\text{and} \qquad 0 < w_3/w_2 < 1 \ . \tag{3}$$

A further restriction is necessary since values of w_2/w_1 and w_3/w_2 too near zero or unity are also undesirable. This would mean that either a second or third place vote received a weight of zero, or that they are weighted equally with a first or second place vote, respectively. Therefore, the inequalities in (3) above can be rewritten

$$0 < a_1 \leq w_2/w_1 \leq b_1 < 1$$
$$\text{and} \qquad 0 < a_2 \leq w_3/w_2 \leq b_2 < 1 \ . \tag{4}$$

Thus, (a_1,b_1) and (a_2,b_2) define a preferential region interior to the unit square. Figure 5 shows such a preferential region when $a_1 = a_2 = 1/3$ and $b_1 = b_2 = 2/3$.

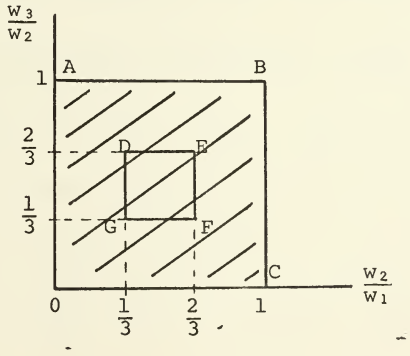

FIGURE 5

Preferential Region For
$a_1 = a_2 = 1/3$ and $b_1 = b_2 = 2/3$

The shaded region represents points satisfying the general constraints in (3) above. The smaller square area DEFG depicts the preferred region where the ratios w_2/w_1 and w_3/w_2 satisfy the constraints in (4). The region outside the larger square OABC violates the inequalities in (2) and (3) above.

Concepts of dominance will now be developed. Let k and k' denote any two teachers. It is desired to find all possible values of $\overline{W}$ so that

$$S_k \geq S_{k'} .$$

Therefore,

$$w_1V_{1k} + w_2V_{2k} + w_3V_{3k} \geq w_1V_{1k'} + w_2V_{2k'} + w_3V_{3k'}$$

or

$$w_1(V_{1k} - V_{1k'}) + w_2(V_{2k} - V_{2k'}) + w_3(V_{3k} - V_{3k'}) \geq 0 . \quad (5)$$

The first form of dominance becomes obvious from (5) above. When $V_{ik} - V_{ik'} > 0$, $i = 1,2,3$, then $S_k > S_{k'}$ and $S_{k'}$ can be eliminated from competition. This form of dominance is termed absolute dominance. (See Table V).

Another form of dominance is readily generated following the observation that (5) defines a straight line in the two dimensional space of Figure 5. From (5),

$$\frac{w_1}{w_2}(V_{1k} - V_{1k'}) + (V_{2k} - V_{2k'}) + \frac{w_3}{w_2}(V_{3k} - V_{3k'}) \geq 0$$

and

$$\frac{w_3}{w_2} \geq -\frac{V_{1k} - V_{1k'}}{V_{3k} - V_{3k'}} \frac{w_1}{w_2} - \frac{V_{2k} - V_{2k'}}{V_{3k} - V_{3k'}} , \qquad (6)$$

where V_{ik} , $V_{ik'}$, i = 1,2,3 are known. The set (6) can be simplified to

$$\frac{w_3}{w_2} \geq A_{kk'} \frac{w_1}{w_2} + B_{kk'} \qquad (7)$$

where $A_{kk'}$ and $B_{kk'}$ are known constants. Consequently, the set (7) defines a half-space in which S_k dominates $S_{k'}$.

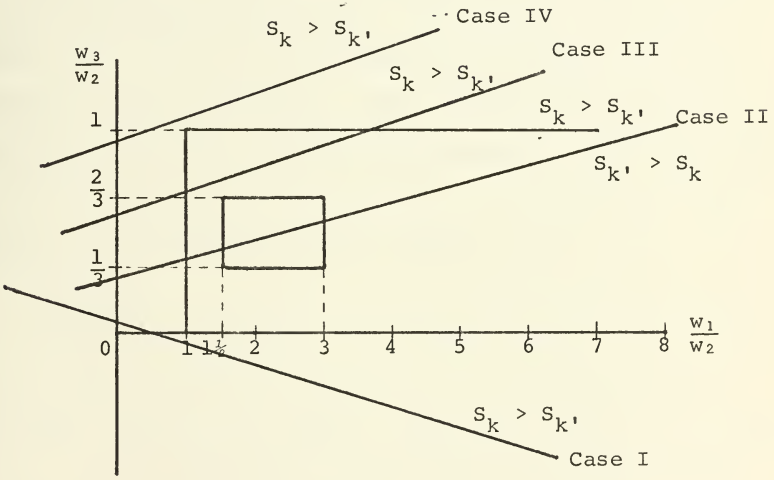

FIGURE 6

Case Examples of Dominance

Figure 6 is a plot of w_3/w_2 vs. w_1/w_2 . Converting the old limits of w_2/w_1 to new limits for w_1/w_2 yields

$$1 < 3/2 \leq w_1/w_2 \leq 3 < \infty \qquad (8)$$

These limits are plotted in Figure 6, together with four cases of dominance.

In Case I, all the points that are feasible, those that satisfy (2) and (3) above, lie in the half-space where $S_k > S_{k'}$. This is termed complete dominance. Absolute dominance is observed to be a special case of complete dominance. Case III may be called incomplete dominance; that is, where $S_k > S_{k'}$ over portions of the feasible region, but not any of the preference region. In Case IV, the points necessary for $S_k > S_{k'}$ are infeasible, resulting in S_k's elimination from competition. Case II represents the most interesting situation. In this case, both S_k and $S_{k'}$ have the feasible and preferential ability to eliminate the other depending on the selected weight system.

3. Results

In the actual data, only thirteen teachers out of 249 remained after an initial screening for absolute dominance. A secondary screeing for complete dominance reduced the group to four. A final screening for incomplete dominance further reduced the eligible teachers to a group of three.

Figure 7 shows the results of this analysis. Let T_1, T_2, and T_3 be the teachers surviving the dominance screening criteria. From the data, $S_1 > S_2$ when

$$\frac{w_3}{w_2} > .73 \frac{w_1}{w_2} - 1.04 .$$

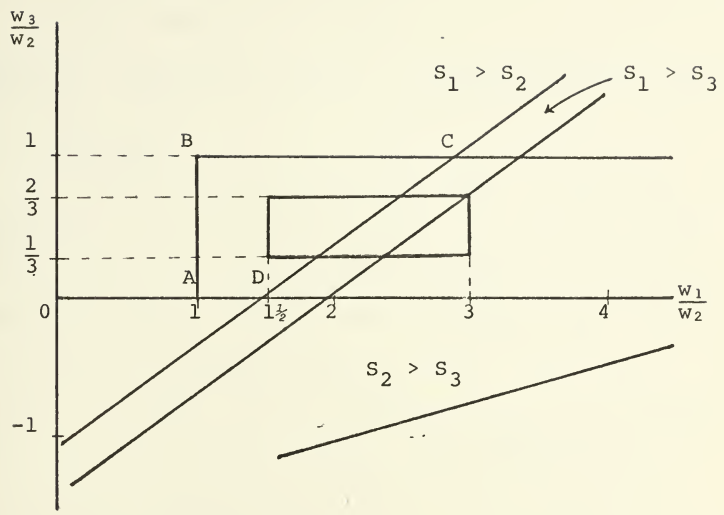

FIGURE 7

Results of Dominance Techniques

This region is represented by the trapezoidal figure ABCD. Similarly, $S_2 > S_3$ when

$$\frac{w_3}{w_2} > .25\,\frac{w_1}{w_2} - 3.61$$

and $S_1 > S_3$ when

$$\frac{w_3}{w_2} > .68\,\frac{w_1}{w_2} - 1.28\ .$$

These dominance lines generated areas where T_1, T_2, and T_3 could win the poll based on score alone, given that the point $\left(\frac{w_1}{w_2}, \frac{w_3}{w_2}\right)$ fell into their respective regions. Several

further analyses of the data were made in an effort to choose among the three undominated teachers.

B. PRINCIPAL COMPONENT ANALYSIS -- DETERMINATION OF WEIGHTS

1. Background

For purposes of preliminary analysis of the data, it was convenient to use tentative weights for first, second, and third place votes, and to rank the teachers according to the resulting scores. Several sets of weights were suggested by the Selection Committee (such as 3:2:1 and 4:2:1) and ultimately the system 4:2:1 was chosen for use in the distribution and correlation studies. This selection was influenced by the following analysis.

It is reasonable to choose weights that would maximize the variance of the scores. This would facilitate ranking the teachers in a preferred order and reduce the number of scores very close together. In two dimensions, a teacher's score could be represented by $S = w_1x_1 + w_2x_2$, which when graphed, becomes a straight line in the (x_1,x_2) space. Figure 8 is such a plot.

In three dimensions, these lines become planes and the objective in either case is to spread these lines or planes as far apart as possible. The method of principal components was used to obtain the set of weights that would accomplish this objective.

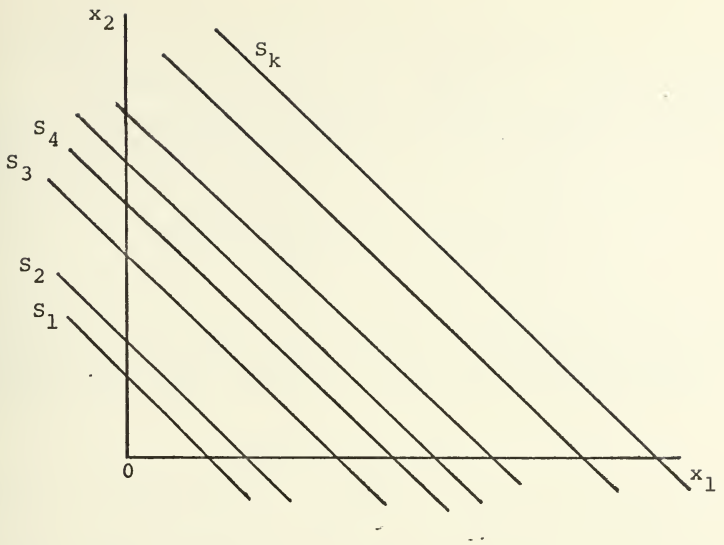

FIGURE 8

Two-Dimensional Plot of (x_1, x_2).

2. Development

Teacher k's score, S_k, can be represented by

$$S_k = \sum_{i=1}^{3} w_i V_{ik} = \overline{W} \cdot \overline{V}_k ,$$

where $\overline{W}$ is the desired weighting system. The objective is to choose $\overline{W}$ so as to $\text{Max}\left[\text{Var}(S_k)\right]$. Since the scores could be made arbitrarily large by letting $\overline{W}$ be unbounded, a constraint on $\overline{W}$ is needed to solve the mathematical problem. It is convenient to use the form

$$\overline{W}'\overline{W} = 1 \qquad (9)$$

to constrain the weight vector.

Define $\bar{V} = (\bar{V}_1, \bar{V}_2, \bar{V}_3)$, where $\bar{V}_i$ is the average value of the fraction of first, second, and third place votes taken over all teachers,

$$\bar{V}_i = \frac{1}{M_0} \sum_{k=1}^{M_0} V_{ik} \ , \quad i = 1,2,3$$

and where M_0 is the total number of teachers identified by the ballots. The variance of the scores can be written

$$\text{Var}(S_k) = \bar{W}' \ C \ \bar{W} \ , \tag{10}$$

where C is the square, symmetric variance-covariance matrix of the V_{ik}'s , i.e.

$$c_{ij} = E\left[(V_{ik} - \bar{V}_i)(V_{jk} - \bar{V}_j)\right] \qquad \begin{matrix} i,j = 1,2,3 \\ \forall\ k \end{matrix} .$$

Combining the objective function and the constraint on $\bar{W}$ into the classical Lagrangian for the maximization problem yields

$$L(\bar{W},\lambda) = \bar{W}' \ C \ \bar{W} - \lambda(\bar{W}' \ \bar{W} - 1) \ , \tag{11}$$

where λ is the Lagrange multiplier. Equation (11) can be rewritten to facilitate obtaining the partial derivatives,

$$L(\bar{W},\lambda) = \sum_{j=1}^{3} \sum_{i=1}^{3} w_i c_{ij} w_j - \lambda\left(\sum_{i=1}^{3} w_i^2 - 1\right) . \tag{12}$$

Taking the partial derivatives with respect to $\bar{W}$ and λ and setting them equal to zero to obtain the maximizing value of $\bar{W}$ yields:

$$\frac{\partial L(\bar{W},\lambda)}{\partial \bar{W}} = 2\ C\ \bar{W} - 2\ \lambda\ \bar{W} = 0 \qquad (13a)$$

and $$\frac{\partial L(\bar{W},\lambda)}{\partial \lambda} = \bar{W}'\ \bar{W} - 1 = 0\ . \qquad (13b)$$

Rearranging (13a), $(C - \lambda I) \cdot \bar{W} = 0$, results in a system of 3X3 linear, homogeneous equations. Their solution is either trivial, $\bar{W} = 0$, or the coefficient matrix is singular,

$$|C - \lambda I| = 0\ . \qquad (14)$$

It should be noted that (14) is the characteristic equation, a third degree polynomial in λ, where the λ's now also represent eigenvalues associated with the covariance matrix. From (13a) above,

$$C\ \bar{W} = \lambda\ \bar{W}\ ,$$

and $$\mathrm{Var}(S_k) = \bar{W}'\ C\ \bar{W}$$

$$= \bar{W}'\ \lambda\ \bar{W} = \lambda\ \bar{W}'\ \bar{W}\ ,$$

and using (13b), $\mathrm{Var}(S_k) = \lambda$. Thus, it follows that $\mathrm{Var}(S_k)$ is maximized when λ is maximized, and that the set of weights maximizing λ is the eigenvector associated with λ. Therefore, utilizing as the weighting system the eigenvector associated with the largest eigenvalue of the characteristic equation, results in a system that separates the scores as much as possible.

A fundamental fault with this approach concerns the satisfaction of the general and preferential restrictions on $\overline{W}$. There is no guarantee that $w_1 > w_2 > w_3$ will occur or that the inner restrictions (a_1,b_1) and (a_2,b_2) will be satisfactory.

3. Results

From the data collected,

$$C = \begin{pmatrix} .0087 & .0035 & .0017 \\ .0035 & .0035 & .0015 \\ .0017 & .0015 & .0021 \end{pmatrix} ,$$

The largest eigenvalue is $\lambda = .011$, and the associated eigenvector is $\overline{W} = (.86,.45,.24)$. This vector was modified to the simpler form $\overline{W} = (4,2,1)$. Since both general and preferential limits were satisfied, $(4,2,1)$ was used to weight first, second, and third place votes with the added knowledge that the resulting scores would be relatively well spread apart.

C. PAIRED COMPARISONS ANALYSIS

A special study was conducted on the top twenty teachers, where the top twenty was defined to be the twenty highest scoring teachers. This study consisted of comparing each pair of the twenty. For each pair, the score was based only on that sub-population of voters that identified both teachers.

Define $T_1,T_2, \ldots, T_{20}$ to be the top twenty teachers ranked in decreasing order of score. In this paired comparison analysis, T_1 would be expected to win over all others,

and T_{20} would be expected to lose. If T_1 lost in any of these tests, significant argument might be made for giving the award to another high ranking teacher, say T_2 or T_3.

Again, let k and k' denote any two teachers and now let $N_{kk'}$ be the size of the population of voters knowing both teachers. Clearly, $\{N_{k'k}\} = \{N_{kk'}\} = N$. Table VI is a display of the square, symmetric matrix N.

Define a new score, $S_{kk'}$, to be the score of teacher k based on the sub-population, $\{N_{kk'}\}$. Similarly, let $S_{k'k}$ be the score of teacher k' based on $\{N_{kk'}\}$. Table VII is the square matrix of $S_{kk'}$. In general, $S_{k'k} \neq S_{kk'}$ and the matrix in Table VII is not symmetric.

Table VIII shows the results of such a paired comparison analysis for the top five teachers ranked as described above. Looking at the analysis for T_1, $N_{kk'}$ is defined as above, T_k is the teacher with whom T_1 is being compared, S_1/S_k is the ratio of S_{1k}/S_{k1}, where S_{1k} and S_{k1} are defined as above, and the plus sign is interpreted to mean that $S_1 > S_k$, and a minus to indicate a reversal, meaning $S_k < S_1$. It is significant to note that T_1 loses twice and ties once under such an analysis.

The importance of the size of $N_{kk'}$ was noted by the selection committee, and consequently, only reversals that occurred with larger values of $N_{kk'}$ were considered relevant. Table VIII is ranked under each teacher by order of decreasing $N_{kk'}$.

TABLE VI

N MATRIX

0	1	19	1	0	2	13	0	0	0	6	4	0	17	5	1	1	3	0	1
1	0	13	1	7	0	7	17	13	0	3	6	1	0	6	0	4	4	0	1
19	13	0	3	11	3	11	4	8	1	2	38	4	15	15	1	6	20	3	3
1	1	3	0	2	1	6	1	0	1	24	2	2	1	2	11	4	1	0	0
0	7	11	2	0	2	5	2	4	2	2	12	28	1	62	1	4	5	15	4
2	0	3	1	2	0	2	0	0	0	0	7	1	10	1	0	1	15	0	1
13	7	11	6	5	2	0	3	9	1	0	8	5	0	9	4	33	7	0	1
0	17	4	1	2	0	3	0	3	4	3	1	2	2	3	0	1	0	0	30
0	13	8	0	4	0	9	3	0	2	9	5	8	3	6	1	2	4	0	5
0	0	1	1	2	0	1	4	2	0	3	1	34	4	2	1	0	1	0	4
6	3	2	24	2	0	0	3	9	3	0	0	3	8	2	2	2	0	0	8
4	6	38	2	12	7	8	1	5	1	0	0	4	2	27	0	3	23	11	0
0	1	4	2	28	1	5	2	8	34	3	4	0	5	17	0	2	3	2	5
17	0	15	1	1	10	0	2	3	4	8	2	5	0	1	0	2	1	0	1
5	6	15	2	62	1	9	3	6	2	2	27	17	1	0	1	4	7	49	1
1	0	1	11	1	0	4	0	1	1	2	0	0	0	1	0	3	0	0	0
1	4	6	4	4	1	33	1	2	0	2	3	2	2	4	3	0	3	0	2
3	4	20	1	5	15	7	0	4	1	0	23	3	1	7	0	3	0	0	1
0	0	3	0	15	0	0	0	0	0	0	11	2	0	49	0	0	0	0	0
1	1	3	0	4	1	1	30	5	4	8	0	5	1	1	0	2	1	0	0

TABLE VII

S MATRIX

	1	2	3	4	5	6	7	8	9	10
1	0.0	0.0	1.26	2.00	0.0	2.00	2.77	0.0	0.0	0.0
2	0.0	0.0	1.23	4.00	0.57	0.0	1.14	3.65	2.15	0.0
3	3.26	0.46	0.0	1.33	0.55	2.00	0.91	0.0	0.50	2.00
4	1.00	0.0	0.0	0.0	1.00	0.0	0.83	0.0	0.0	0.0
5	0.0	0.57	0.64	2.00	0.0	2.00	0.0	0.0	0.0	2.00
6	2.00	0.0	1.33	0.0	0.50	0.0	0.0	0.0	0.0	0.0
7	1.69	0.14	0.09	0.67	0.0	0.0	0.0	0.0	0.78	1.00
8	0.0	1.29	0.75	0.0	0.0	0.0	0.0	0.0	0.67	0.50
9	0.0	0.38	0.50	0.0	1.00	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	3.00	0.0	0.0	1.00	0.0	0.0
11	1.17	1.33	2.00	1.50	0.0	0.0	0.0	0.33	0.67	0.67
12	0.75	0.0	0.45	0.50	1.50	0.29	0.13	0.0	0.0	0.0
13	0.0	0.0	1.00	2.00	1.29	0.0	1.20	4.00	0.75	0.56
14	0.41	0.0	0.73	0.0	0.0	0.50	0.0	2.00	3.33	0.0
15	0.20	0.0	0.53	0.0	1.31	0.0	0.44	2.00	0.0	0.0
16	0.0	0.0	4.00	0.91	0.0	0.0	1.00	0.0	2.00	0.0
17	0.0	0.0	0.0	0.50	0.0	0.0	1.39	0.0	0.0	0.0
18	0.0	0.0	0.45	2.00	0.40	0.93	0.29	0.0	0.0	0.0
19	0.0	0.0	0.67	0.0	0.73	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	1.50	1.00	0.0	1.50	0.0	0.25

TABLE VII (CONT'D)

S MATRIX

	11	12	13	14	15	16	17	18	19	20
1	0.50	3.00	0.0	0.94	4.00	2.00	0.0	2.67	0.0	0.0
2	1.33	1.33	0.0	0.0	0.67	0.0	1.00	1.00	0.0	0.0
3	0.0	2.29	1.50	3.47	0.53	0.0	0.67	1.85	0.0	0.0
4	2.33	0.0	0.0	4.00	0.0	2.00	1.25	0.0	0.0	0.0
5	0.0	0.17	1.75	4.00	2.03	4.00	0.0	0.0	0.80	1.00
6	0.0	2.29	0.0	1.70	0.0	0.0	0.0	1.87	0.0	0.0
7	0.0	0.13	0.20	0.0	0.33	1.00	1.85	0.14	0.0	0.0
8	0.0	0.0	0.0	0.50	0.0	0.0	1.00	0.0	0.0	1.03
9	3.44	0.80	2.25	0.33	0.83	1.00	0.0	0.0	0.0	0.20
10	1.33	0.0	2.00	3.00	2.00	0.0	0.0	0.0	0.0	1.00
11	0.0	0.0	0.67	1.38	0.0	0.50	2.00	0.0	0.0	2.00
12	0.0	0.0	0.25	2.00	2.30	0.0	0.33	0.65	2.91	0.0
13	0.0	0.0	0.0	0.80	0.88	0.0	0.0	0.0	0.0	1.20
14	0.13	0.50	0.0	0.0	2.00	0.0	0.0	0.0	0.0	0.0
15	0.0	1.15	1.12	0.0	0.0	0.0	0.0	0.29	1.82	0.0
16	2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.67	0.0	0.0	0.0	0.0
18	0.0	1.09	0.67	0.0	0.29	0.0	0.67	0.0	0.0	0.0
19	0.0	0.55	0.0	0.0	1.20	0.0	0.0	0.0	0.0	0.0
20	0.13	0.0	1.60	0.0	0.0	0.0	0.0	1.00	0.0	0.0

TABLE VIII

PAIRED COMPARISONS SUMMARY

T_1				T_2				T_3				T_4				T_5			
N_{1k}	T_k	S_1/S_k	±	N_{2k}	T_k	S_2/S_k	±	N_{3k}	T_k	S_3/S_k	±	N_{4k}	T_k	S_4/S_k	±	N_{5k}	T_k	S_5/S_k	±
19	3	1.26 / 3.26	-	17	8	3.65 / 1.29	+	38	12	2.29 / .45	+	24	11	2.33 / 1.50	+	62	15	2.03 / 1.31	+
17	14	.94 / .41	+	13	3	1.23 / .46	+	20	18	1.85 / .45	+	11	16	2.00 / .91	+	28	13	1.75 / 1.29	+
13	7	2.77 / 1.69	+	13	9	2.15 / .38	+	19	1	3.26 / 1.26	+	6	7	.83 / .67	+	15	19	.8 / 0	+
6	11	.5 / 1.17	-	7	5	.57 / .57	0	15	14	3.47 / .73	+	4	17	1.25 / .50	+	12	12	.17 / 1.50	-
5	15	4.00 / .2	+	7	7	1.14 / .14	+	15	15	.53 / .53	0	3	3	0 / 1.33	-	11	3	.64 / .55	+
4	12	3.00 / .75	+	6	12	1.33 / 0	+	13	2	.46 / 1.23	-	2	5	1.00 / 2.00	-	7	2	.57 / .57	0
3	18	2.67 / 0	+	6	15	.67 / 0	+	11	5	.55 / .64	-	2	12	0 / .50	-	5	7	0 / 0	
2	6	2.00 / 2.00	0	4	17	1.00 / 0	+	11	7	.91 / .09	+	2	13	0 / 2.00	-	5	18	0 / .4	-
1	2	0 / 0		4	18	1.00 / 0	+	8	9	.5 / .5	0	2	15	0 / 0		4	9	0 / 1.00	-
1	4	2.00 / 1.00	+	3	11	1.33 / 1.33	0	6	17	.67 / 0	+	1	1	1.00 / 2.00	-	4	17	0 / 0	
1	16	2.00 / 0	+	1	1	0 / 0		4	8	0 / .75	-	1	2	0 / 4.00	-	4	20	1.00 / 1.50	-
1	17	0 / 0		1	4	4.00 / 0	+	4	13	1.50 / 1.00	+	1	6	0 / 0		2	4	2.00 / 1.00	+
1	20	0 / 0		1	13	0 / 0		3	4	1.33 / 0	+	1	8	0 / 0		2	6	2.00 / .5	+
				1	20	0 / 0		3	6	2.00 / 1.33	+	1	10	0 / 0		2	8	0 / 0	

TABLE VIII (CONT'D)

PAIRED COMPARISONS SUMMARY

T_1				T_2				T_3				T_4				T_5			
N_{1k}	T_k	S_{1/S_k}	$\pm$	N_{2k}	T_k	S_{2/S_k}	$\pm$	N_{3k}	T_k	S_{3/S_k}	$\pm$	N_{4k}	T_k	S_{4/S_k}	$\pm$	N_{5k}	T_k	S_{5/S_k}	$\pm$
								3	19	$\frac{0}{.67}$	-	1	14	$\frac{4.00}{0}$	+	2	10	$\frac{2.00}{3.00}$	-
								3	20	$\frac{0}{0}$		1	18	$\frac{0}{2.00}$	-	2	11	$\frac{0}{0}$	
								2	11	$\frac{0}{2.00}$	-					1	14	$\frac{4.00}{0}$	+
								1	10	$\frac{2.00}{0}$	+					1	16	$\frac{4.00}{0}$	+
								1	16	$\frac{0}{4.00}$	-								

LEGEND

$N = N_{kk'} = N_{k'k}$

T_k = teacher k

$S_{i/S_k} = \frac{\text{teacher i's score}}{\text{teacher k's score}}$

$\pm$ = + if teacher i wins
- if teacher k wins
0 if tie

$\frac{0}{0}$ = blank, signifies no contest

D. SCATTER DIAGRAM ANALYSIS OF S_k vs. N_k

An analysis was conducted on the relationship between S_k and N_k, where S_k was the score received by teacher k and N_k was the voter population familiar with teacher k.

It would be ridiculous to give the award to the teacher who received a perfect score because one person knew him and nominated him for first place. Thus, in this analysis, it was desired to identify a subgroup of high scores that were associated with small N_k, if any existed; and if so, exclude these from competition. Figure 9 is a scatter diagram of S_k vs. N_k. From the diagram, it was concluded that this problem did not exist and therefore, a procedure for dissecting this space into two half-spaces, one that would be acceptable for further analysis and one that would be eliminated, was not researched.

Another purpose of this analysis was to determine if any correlation of S_k with N_k could be made, either positively or negatively. If it could be concluded that the regression coefficient did not equal zero, then it would have been necessary to find a different function of the polling data to serve as the score, one that was not correlated with N_k.

Figure 9 again demonstrated that no correlation could be made and that the regression coefficient required would be zero, thus rendering the preceding analyses valid.

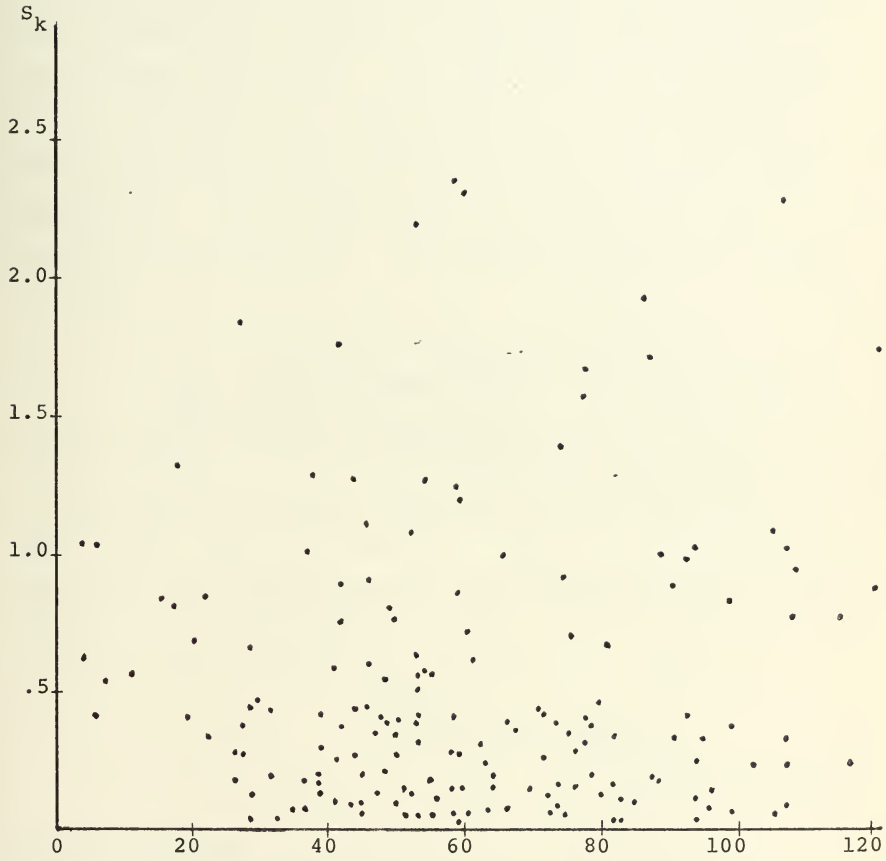

FIGURE 9

Scatter Diagram of S_k vs. N_k

E. SCORE DISTRIBUTION ANALYSIS

Another special study was concerned with a determination of the distribution of the positive scores. With this knowledge, probability statements and analyses could be made to a high degree of accuracy. The first step in this direction was the construction of a histogram of S_k (see Figure 10). The histogram showed that the scores have a reverse-J shaped distribution. To estimate the form, the empirical tail-distribution was computed. The results are printed in Table IX, where

N is the number of positive scores
f_j is the frequency of the j^{th} scoring-cell,
TF is the tail frequency,
and $RTF = TF/N$ is the relative tail frequency.

From Table IX, a semi-logarithmic plot of score-cell midpoint against RTF was examined. Figure 11 was the resulting plot and it was concluded that a straight line could be meaningfully fitted to the data. Letting

$$y = RTF$$
and $$x = \text{score-cell midpoint},$$

$\log_{10} y = -.909x$, and converting to the natural logarithm,

$$.434 \ln y = -.909x$$
or $$\ln y = -2.09x$$
and therefore, $y = e^{-2.09x}$. Consequently, $P(X > x) = e^{-2.09x}$, and this would yield an estimated

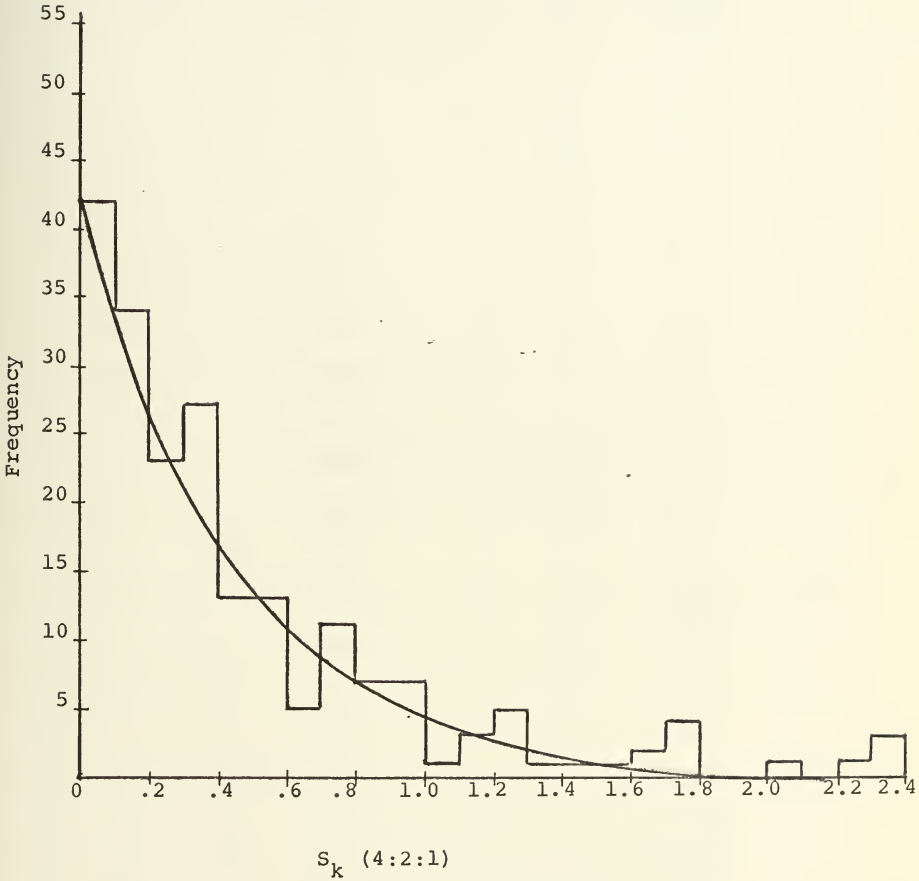

FIGURE 10

Histogram of S_k

TABLE IX

EMPIRICAL TAIL-DISTRIBUTION DATA

j	Cell	Cell Mp	F_j	TF	RTF($\frac{TF}{N}$)	lnRTF
1	.001 - .1	.050	42	163	.7955	-.2295
2	.101 - .2	.150	34	129	.6295	-.4630
3	.201 - .3	.250	23	106	.5170	-.6600
4	.301 - .4	.350	27	79	.3855	-.9550
5	.401 - .5	.450	13	66	.3218	-1.1350
6	.501 - .6	.550	13	53	.2585	-1.3500
7	.601 - .7	.650	5	48	.2342	-1.4500
8	.701 - .8	.750	11	37	.1805	-1.7130
9	.801 - .9	.850	7	30	.1463	-1.9200
10	.901 - 1.0	.950	7	23	.1122	-2.1900
11	1.001 - 1.1	1.050	1	22	.1073	-2.2400
12	1.101 - 1.2	1.150	3	19	.0927	-2.3800
13	1.201 - 1.3	1.250	5	14	.0683	-2.6850
14	1.301 - 1.4	1.350	1	13	.0634	-2.7600
15	1.901 - 1.5	1.450	1	12	.0586	-2.8400
16	1.501 - 1.6	1.550	1	11	.0537	-2.9200
17	1.601 - 1.7	1.650	2	9	.0439	-3.1300
18	1.701 - 1.8	1.750	4	5	.0244	-3.7200
19	1.801 - 1.9	1.850	0	5	.0244	-3.7200
20	1.901 - 2.0	1.950	0	5	.0244	-3.7200
21	2.001 - 2.1	2.050	1	4	.0195	-3.9300
22	2.101 - 2.2	2.150	0	4	.0195	-3.9300
23	2.201 - 2.3	2.250	1	3	.0146	-4.2400
24	2.301 - 2.4	2.350	3	0	.000	∞

N = 205

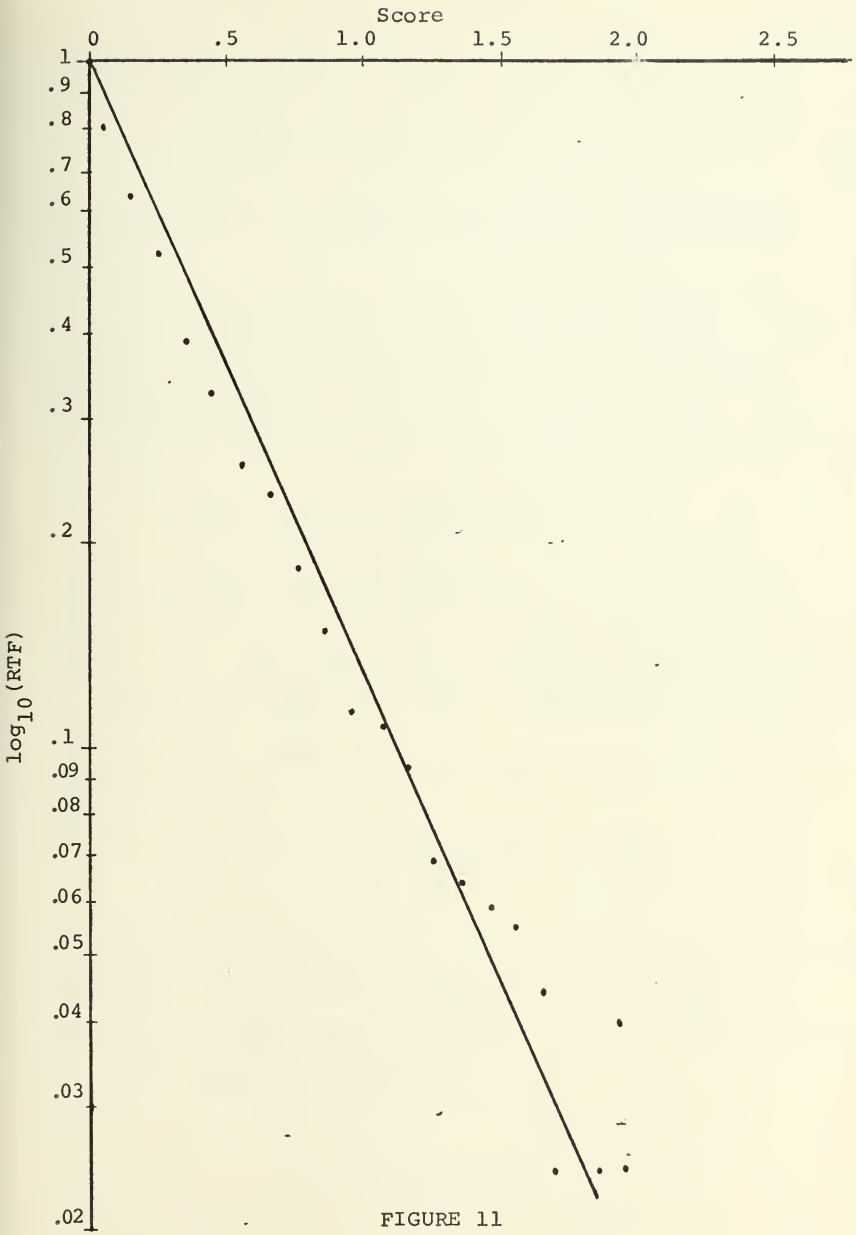

FIGURE 11

Semi-Logarithmic Plot of Score-Cell Midpoint vs. RTF

density function of S_k to be

$$f_S(s) = 2.09e^{-2.09s} \quad , \quad s > 0 \qquad (15)$$

The smooth curve on Figure 10 is a plot of this density function.

It was desired to test the statistical validity of this density function as a true representation of the data. A Chi-Square Goodness-of-Fit Test was chosen. Table X is a collection of the data used in the Goodness-of-Fit test for

H_0: $f_S(s) = 2.09e^{-2.09s}$, $s > 0$

H_1: H_0 false, where

$I_1, I_2, \ldots, I_{14}$ represent the scoring intervals, $p_i = P(S \in I_i)$ under H_0 , Np_i is the expected number of entries in I_i under H_0 , and x_i is the number of observed entries in I_i .

Define $U = \sum_{i=1}^{k} \frac{(x_i - Np_i)^2}{Np_i}$, where U is a random variable that approaches the Chi-Square Distribution function with k-2 degrees of freedom as $n \to \infty$. Then, H_0 should be accepted with probability of Type I error equal to α , if the observed value of U ,

$$u < \chi^2_{k-2}(1 - \alpha) \ .$$

TABLE X

Chi-Square Goodness-of-Fit Test Data

i	I_i	$P_i = P(S \in I_i)$ under H_0	Np_i	X_i
1	$\{S_k \mid S_k \leq .1\}$	.188	38.6	42
2	$\{S_k \mid .1 < S_k \leq .2\}$	.153	31.4	34
3	$\{S_k \mid .2 < S_k \leq .3\}$	.124	25.4	23
4	$\{S_k \mid .3 < S_k \leq .4\}$	.101	20.7	27
5	·	.081	16.6	13
6	·	.067	13.7	13
7	·	.054	11.1	5
8	·	.043	8.8	11
9	·	.035	7.2	7
10	$\{S_k \mid .9 < S_k \leq 1.0\}$	.030	6.2	7
11	$\{S_k \mid 1.0 < S_k \leq 1.2\}$	.042	8.6	4
12	$\{S_k \mid 1.2 < S_k \leq 1.4\}$	.028	5.7	6
13	$\{S_k \mid 1.4 < S_k \leq 1.7\}$	.025	5.1	4
14	$\{S_k \mid S_k > 1.7\}$	.029	5.9	9

From the observed data, $u = 11.83$, and from the χ^2 distribution with twelve degrees of freedom and $\alpha = .05$, $\chi^2_{12}(.95) = 21.0$. Therefore,

$$u < \chi^2_{12}(.95) \quad \text{and} \quad H_0 \quad \text{is accepted.}$$

Since the hypothesized density function passed the Chi-Square Test, it was concluded that (15) above was an acceptable description of the observed scores.

F. CORRELATION ANALYSIS

The correlation analyses below were designed to aid future committees by providing a better understanding of the voter population.

1. Coefficient of Concordance Analyses

Appendix B is a display of data used to estimate the effect of age of the voters. It was desired to know if the ratings of the teachers were somehow dependent upon the age of the individual voter. To accomplish this, Kendall's Coefficient of Concordance was applied to the ranking of sixty-two teachers by two separate subgroups of the voter population. Since military rank is, for the most part, proportional to age, it was felt that a ranking of the sixty-two teachers first by the 01's , and secondly by the 04's would give a wide enough spread in rank to encompass the effect of age upon voter nominations. Hence, Appendix B is a 2x62 matrix, where the first row represents the ranking of teachers by the 01's , and the second row by the 04's .

The choice of sixty-two teachers was made because of the following two restrictions. First, it was necessary to restrict the population of teachers to those known by both observer categories. Secondly, it was felt necessary to put a restriction on N_k, the number of ballots identifying teacher k, in each voter category. Consequently, each of the sixty-two teachers eligible for ranking were known by both the 01's and the 04's; and in addition, at least five ballots from the population of 01's and at least five from the 04's identified each teacher.

From Kendall [Ref. 3],

$$W = \frac{12S}{m^2(n^3 - n) - 12m \sum T_i} \quad , \quad 0 \leq W \leq 1 \ ,$$

where W is the Coefficient of Concordance modified to compensate for the existence of ties within rankings. The observed data yielded

$$S = 69{,}504$$
$$m = 2$$
$$n = 62$$
$$T_1 = 781$$
$$T_2 = 182$$

and $W = .89$.

The statistic W measures the communality of judgment between the two rankings. Thus, a W close to one, such as the above, indicates a high degree of concordance between rankings, and from the above test, it can be concluded that

age was not an important factor in how a voter rated the teachers.

At this point, some measure of the significance of this observed value of W is needed. Such a measure is offered by Kendall, utilizing the Chi-Square distribution. Define

$$U = \frac{12S}{mn(n+1)}$$

$$= m(n-1)W \ .$$ Then U is approximately distributed as $\chi^2_\nu(1-\alpha)$ with $\nu = n-1$ degrees of freedom. From the observed data, $u = 108.5$. Since $\nu = 61 (> 30)$ degrees of freedom,

$$\sqrt{2\chi^2_{61}} \sim N(11,1)$$

or $$\sqrt{2\chi^2_{61}} - 11 \sim N(0,1)$$

or $$(\sqrt{2\chi^2_{61}} - 11 > z) = .01 \ , \text{ which implies}$$

$$\sqrt{2\chi^2_{61}} - 11 > 2.23 \ .$$

Thus, $\chi^2_{61} > 87.5$ specifies the critical region. Therefore, the observed value of U ,

$u = 108.5 > \chi^2_{61} = 87.5$, and it is concluded that the resulting W above is substantially significant.

For determining the effect of military rank on voter choice, a Kendall Coefficient of Concordance was computed for

the subpopulation of voters consisting of the 03's , 04's , and 05's , a large group that had all ranked a common large number of teachers. The test was conducted under the same restrictions as above. Appendix C shows the 3x91 matrix of rankings. These data yielded

$$W = .82$$

and $u = 222$. Consequently,

$u = 222 > \chi^2_{90} = 122$, and therefore, from this analysis, it was concluded that Military Rank did not influence the pattern of voter nominations.

A Coefficient of Concordance was developed for the rankings of the Faculty and those of the Students. It was desired to know if the Faculty in general, would vote as did the Students. Similar restrictions as those above were introduced to obtain more meaningful results. Appendix D displays the 2x193 matrix utilized in the test, with the following results:

$$W = .73$$

and $u = 280$. Consequently,

$u = 280 > \chi^2_{192} = 238$, and $W = .73$ is "just significant" at $\alpha = .01$. Therefore, it was concluded that both Students and Faculty generally agreed on their choices.

Similarly, it was desired to know how the Alumnus would compare to the Faculty in such a test. Appendix E displays the

2x115 matrix of data. Restrictions such as those above were introduced with the following results:

$W = .65$

and $u = 148$. Consequently,

$u = 148 < \chi^2_{114} = 150$, and it was concluded that $W(= .65)$ was not significant at $\alpha = .01$. In other words, it could have arisen by chance from a population where Faculty and Alumnus were completely unrelated.

The tests of hypothesis for significance had as the null hypothesis and alternative,

H_0: W is not significant

H_1: W is significant.

At times, it would be more meaningful to know the value of α at which the decision regarding H_0 would just be changing from accept to reject, given the test statistic. This value of α is called the P-value [Ref. 1] and is commonly used as a substitute for the critical point. Thus, $P = P(W \geq$ the observed W). The P-value for the above calculations are determined as follows:

Let u* be the observed value of the test statistic. Then

$$\frac{\sqrt{2u^*} - \mu_\nu}{\sigma_\nu} = z_{1-P},$$

where μ_ν and σ_ν are the mean and standard deviation of the Normal distribution approximation of the Chi-Square distribution with $\nu > 30$, and z_{1-P} is the $100(1-P)$

percentile of this Normal distribution. Now,

$$1 - P = N_z(z_{1-P})$$

and $P = 1 - N_z(z_{1-P})$, where $N_z(z_{1-P})$ is the value of the cumulative distribution function of the Standard Normal at z_{1-P} .

The results of the Concordance Analyses with their respective P-values are summarized in Table XI below.

TABLE XI

Coefficient of Concordance Summary

Observers	W	P-Value
01's and 04's	.89	10^{-4}
03's, 04's and 05's	.82	$< 10^{-4}$
Faculty and Students	.73	$< 10^{-4}$
Alumnus and Faculty	.65	.018

It was concluded that the Faculty and Students, in general, agreed upon their choices and that within the Students, agreement was high regardless of age or rank. The lower value for W , although not significant at $\alpha = .01$, noted in the test of Alumnus and Faculty would indicate that graduate views differ from current Students and Faculty.

2. Contingency Table Analyses

It was desired to know if Academic Rank was associated with score. A contingency table was developed for Score Category vs. Academic Rank. This test could then conclude whether or not scoring was independent of the rank of the teachers

concerned; and consequently, whether or not the voter population favored one or more of the teacher categories. Therefore, it was desired to test

$$H_0: \ P_{ij} = w_i s_j$$

against $H_1: \ P_{ij} \neq w_i s_j$, where

$$P_{ij} = P(T_k \in (i,j)^{th} \text{ cell})$$

$$w_i = P(T_k \in i^{th} \text{ score category})$$

and $s_j = P(T_k \in j^{th} \text{ academic rank})$.

TABLE XII

Contingency Table For

Score Category vs. Academic Rank

		Academic Rank				
		Prof	Acco	Asst	Inst	total
Score Category	.0001 .1200	16 16.0	14 17.3	10 13.2	8 6.6	48
	.1201 .2400	11 11.1	10 12.0	11 9.2	5 4.6	37
	.2401 .4300	10 13.5	21 14.7	10 11.2	4 5.6	45
	.4301 .7300	12 8.8	5 9.5	9 7.2	3 3.6	29
	.7301 4.000	14 13.5	13 14.7	12 11.2	6 5.6	45
	total	63	68	52	26	204

Table XII displays the data in a contingency table. Each interior cell has two entries. The upper entry represents the observed number of teachers of academic rank j scoring in score category i. The lower entry of each cell is the number of entries that should be in the cell if H_0 is true. These numbers were found using the maximum likelihood estimators for w_i and s_j [Ref. 4]:

$$\hat{W}_i = \frac{1}{n} \sum_{j=1}^{4} X_{ij} \; ; \quad i = 1,2,3,4,5$$

and $$\hat{S}_j = \frac{1}{n} \sum_{i=1}^{5} X_{ij} \; ; \quad j = 1,2,3,4 \; .$$

X_{ij} is the number of observed entries in each cell. Thus, from n sample values,

$$n\hat{W}_i\hat{S}_j = \text{expected number of entries in the } (i,j)^{th} \text{ cell.}$$

Therefore, $$V = \sum_{i=1}^{5} \sum_{j=1}^{4} \frac{(X_{ij} - n\hat{W}_i\hat{S}_j)^2}{n\hat{W}_i\hat{S}_j}$$

is approximated by the Chi-Square distribution function with twelve degrees of freedom. From the observed data,

$$v = 10.2$$

and $$\chi^2_{12}(.95) = 21.0 \; .$$

Since $v < \chi^2_{12}(.95)$, H_0 is accepted with

probability of Type I error, $\alpha = .05$. It was concluded that the scoring distribution was independent of Academic Rank, and that the voter population did not prefer any academic rank in particular.

A word should be said concerning the score categories used above. It was desired to have score categories such that each would encompass an equal number of expected entries; and in addition, that the expected number be greater than or equal to five. To achieve this, the exponential distribution estimated previously was used, through its inverse function, to arrive at five scoring intervals.

TABLE XIII

Contingency Table For

Score Category vs. Student Curricular Area

Score Category	Ops Ana	Ele Eng	Ord Eng	Nav Eng	Eng Sci	Man CSc	Bac Pgm	total
.0001	9	8	7	6	12	5	6	53
.1200	7.0	8.7	7.6	5.7	8.8	8.8	6.5	
.1201	7	9	9	6	11	9	11	62
.2400	8.2	10.1	8.9	6.1	10.3	10.3	7.7	
.2401	9	13	10	5	14	19	11	81
.4300	10.7	13.2	11.7	8.6	13.4	13.4	10.0	
.4301	10	17	18	11	9	10	8	83
.7300	11.0	13.5	12.0	8.9	13.7	13.7	10.2	
.7301	22	23	18	18	25	28	17	151
4.000	20.0	24.6	21.8	16.2	25.0	25.0	18.5	
total	57	70	62	46	71	71	53	430

A similar analysis was made on Score Category vs. Student Curricular Area. Table XIII shows the resulting contingency table. Conclusions as to the independence of score category and individual student curricula were of interest.

The test statistic now becomes

$$V = \sum_{i=1}^{5} \sum_{j=1}^{7} \frac{(X_{ij} - nW_i R_j)^2}{n\hat{W}_i \hat{R}_j} ,$$

where $\hat{R}_j$ is the maximum likelihood estimator of r_j, the probability of falling in the j^{th} curricular area. Thus V is approximated by the Chi-Square distribution function with twenty-four degrees of freedom. From the observed data

$$v = 18.6$$

$$\chi^2_{24}(.95) = 36.4$$

Since $v < \chi^2_{24}(.95)$, the null hypothesis of independence is accepted with $\alpha = .05$.

It was concluded that score category was independent of student curricular area, in that the probability of receiving a score in one of the categories was not dependent upon which student curricula were sampled.

Due to exceptionally low voter response in three curricular areas, only seven curricula were represented in this analysis. It is to be noted that the contingency table

analyses are specific to the scoring intervals chosen. Time constraints precluded deeper analyses of these potential associations.

It was desired to perform a Contingency Table Analysis on Score Category vs. Academic Department. Conclusions as to whether or not the scoring distribution was independent of academic department were of interest. Table XIV is a collection of data for such an analysis. Due to the small expected and observed numbers involved, the analysis was not conducted.

TABLE XIV

Table For Score Category vs. Academic Department

Score Category	Aer Eng	Avi Sty	Man CSc	Ele Eng	Gov Hum	Mat Che	Ma	Mec Eng	Mr	Oc	Ops Ana	Phy	Nav Sys	Tot
.0001 .1200	1	0	3	8	2	4	10	1	3	4	6	6	0	48
.1201 .2400	2	1	2	6	3	1	3	2	1	5	4	7	0	37
.2401 .4300	4	0	7	8	1	3	4	0	1	1	8	7	1	45
.4301 .7300	2	0	1	4	0	3	5	4	0	1	3	5	1	29
.7301 4.000	4	1	5	5	3	0	10	2	4	2	6	2	1	45
Total	13	2	18	31	9	11	33	9	9	13	27	27	3	204

Academic Department

VI. CONCLUSION

Members of the Selection Committee made individual evaluation of the special studies presented above in preparation for their final choice of an award recipient. Following a presentation of the special studies, the committee cast a secret ballot to choose among the remaining three teachers.

The names of individual teachers concerned were unknown to the Selection Committee throughout the process. At the time the above ballot results were revealed, the only name announced was that of the winner. His name was forwarded to the Academic Dean and Superintendent, and will be made public at the June Graduation Ceremonies.

APPENDIX A

SAMPLE BALLOT

AWARD FOR EXCELLENCE IN TEACHING

- Background -

In order to augment the existing incentives for teaching of high quality, the Superintendent has established an award, called the Award for Excellence in Teaching. Having participated in the educational processes at the Naval Postgraduate School, your opinion is of value to the Selection Committee. In order to assess the collective opinion of students, faculty, staff, and selected alumni, the committee is conducting this poll. After accumulating the voting results the committee will select the Award recipient.

The committee, mindful of the many measures of teaching excellence, does not wish to fix the rationale by which each voter determines his nominations. However, in order to assist those voters who desire something more definite as a guide to their thinking, the committee offers the following summary of some aspects of teaching excellence worthy of consideration: "The phrase, 'excellence in teaching,' refers to that complex of personal and professional qualities and actions on the part of the teacher which (a) make themselves felt primarily at the interface of personal contact between student and teacher; (b) help transmute the student's encounters with his subject matter into insight, enlightenment and love of learning; (c) elicit from the student responses in thought, feeling and action which enhance his capacity for self education and (d) manifest themselves in an effective individual style which authentically reflects the teacher's own unique personality, experience, character, and convictions."

A meaningful selection of the Award recipient is heavily dependent upon the receipt of nominations from a large portion of the eligible "voters." Your response is therefore earnestly requested. Please complete the enclosed ballot in accordance with the attached instructions. The results of the polling, other than the Award recipient, will be treated as privileged information by the committee.

BALLOTING PROCEDURE:

Step 0. Complete the information requested at the top of the ballot. These items are for purposes of statistical analyses only.

Step 1. On the list of eligible faculty encircle the number at the left of those with whom you are sufficiently acquainted to make a judgment. Use your own guidelines. For purposes of establishing a population base, it is important to encircle all with whom you are acquainted.

Step 2. From the subset of faculty you have indicated in Step 1, select from one (1) to three (3) nominees. Indicate the order of your preference by placing a number 1, 2, or 3 opposite and to the left of the appropriate name. Numeral "1" indicates the first choice, etc.

Step 3. You are invited to furnish a short statement in support of your primary nomination. Space is provided for this at the and of the ballot.

Step 4. Return the ballot by April 7.

Students: Return to your curricular officer.

Faculty and Staff: Send to Code 55 Bal.

Alumni: Return via the enclosed return envelope.

BALLOT

Part I - Statistical (encircle code at left)

Voter Category

S Student
F Faculty
A Alumnus
C Curricular Officer

Military

Rank

01
02
03
04
05
06
07

Branch of Service

N Navy
M Marine Corps
A Army
C Coast Guard
L Air Force
F Foreign

Curricular Area

30 Ops Analysis
31 Aero Eng
32 Elec & Comm Eng
33 Ordnance
34 Naval Eng
35 Env Sci
36 Manage & Comptr Sci
37 Eng Sci
38 Baccalaureate
39 Oef Management

Civilian

Rank

IR Instructor
AT Assist Prof
AC Assoc Prof
PR Professor

Department

AE Aeronautics
AO Aviation Safety
Mi Bus Ad & Econ
EE Elec Eng
GH Govt & Humanities
MC Mat Sc & Chem
MA Math
ME Mech Eng
MR Meteorology
OC Oceanography
OA Ops Analysis
PH Physics
NS Navy Manage Sys Center

Part II - List of Eligible Faculty (all faculty engaged in teaching in the academic year 1969-70 except department chairmen and members of the selection committee)

Aviation Safety Programs

___ 1014 Bomberger, R. B.
___ 1025 Bradbury, C. M.
___ 1036 Fletcher, J. L.
___ 1047 Wible, L. C.

Department of Aeronautics

___ 1058 Ball, R. E.
___ 1069 Bennett, J. A. J.
___ 1070 Biblarz, O.
___ 1081 Collins, O. J.
___ 1092 Oelph, T. J.
___ 1108 Haupt, U.
___ 1119 Kahr, C. H.
___ 1120 Layton, D. M.
___ 1131 Lindsey, G. H.
___ 1142 Miller, J. A.
___ 1153 Netzer, O. W.
___ 1164 Schmidt, L. V.
___ 1175 Vavra, M. H.
___ 1186 Zucker, R. O.

Department of Business Administration and Economics

___ 1197 Carrick, P. M.
___ 1203 Castro, B.
___ 1214 Church, W. H.
___ 1225 Cowie, J. B.
___ 1236 Oarbyshire, L.
___ 1247 Eisenhardt, P.
___ 1258 Elster, R. S.
___ 1269 Fremgen, J. M.
___ 1270 Ganz, J. G.
___ 1281 Githens, W. H.
___ 1292 Hoverland, H. A.
___ 1308 Jolly, J. A.
___ 1319 Lande, R. S.
___ 1320 Lane, M. L.
___ 1331 Lee, M.
___ 1342 Musgrave, G. L.
___ 1353 Senger, J. O.
___ 1364 Steckler, M. J.
___ 1375 Wegener, W. H.
___ 1386 Womer, N. K.

Department of Electrical Engineering

___ 1397 Badger, R. R.
___ 1403 Bauer, W. M.
___ 1414 Baycura, O. M.
___ 1425 Borst, F. W., Jr.
___ 1436 Bouldry, J. M.
___ 1447 Breida, S.
___ 1458 Campbell, J. O.
___ 1469 Chan, S. G.
___ 1470 Chaney, J. G.
___ 1481 Cooper, P. E.
___ 1492 Cotton, M. L.
___ 1508 Oe Laura, R. O.
___ 1519 Oemetry, J. S.
___ 1520 Ewing, G. O.
___ 1531 Gardner, E. M.
___ 1542 Gerba, A., Jr.
___ 1553 Hoisington, D. V.
___ 1564 Houston, R. K.
___ 1575 Kirk, O. E.
___ 1586 Klamm, C. F., Jr.
___ 1597 Marmont, G. H.
___ 1603 Miller, R. L.
___ 1614 Murray, R. P.
___ 1625 Myers, G. A.
___ 1636 Myers, H. L.
___ 1647 Oler, C. B.
___ 1658 Parker, S. R.
___ 1669 Sackman, G. L.
___ 1670 Sheingold, A.
___ 1681 Smith, W. C.
___ 1692 Stentz, O. A.
___ 1708 Terman, F. W.
___ 1719 Thaler, G. J.
___ 1720 Turner, J. B., Jr.
___ 1731 Vivell, A. E.
___ 1742 Ward, J. R.
___ 1753 Wilcox, M. L.

Department of Government and Humanities

___ 1764 Alexander, W. P., Jr.
___ 1775 Bjarnason, L. L.
___ 1786 Gabel, B. B.
___ 1797 Gottschalk, S.
___ 1803 Huff, B. F.
___ 1814 McAdams, J. M.
___ 1825 Pearson, L. W.
___ 1836 Stolfi, R. H.
___ 1847 Teti, F. M.

Department of Material Science and Chemistry

___ 1858 Clark, J. R.
___ 1869 Helliwell, R. W.
___ 1870 Hering, C. A.
___ 1881 Kinney, G. F.
___ 1892 Marshall, G. D.
___ 1908 McFarlin, G. H.
___ 1919 Reynolds, M. F.
___ 1920 Rowell, C. F.
___ 1931 Schultz, J. W.
___ 1942 Sinclair, J. E.
___ 1953 Tolles, W. M.
___ 1964 Wilson, J. W.

Department of Mathematics

___ 1975 Barksdale, G. L.
___ 1986 Bender, A. P.
___ 1997 Bleick, W. E.
___ 2006 Bolles, R. C.
___ 2017 Brainerd, W. S.
___ 2028 Calabrese, P. G.
___ 2039 Davis, O. L.
___ 2040 Deaton, L. W.
___ 2051 Dixon, O. R.
___ 2062 Estell, R. J.
___ 2073 Faulkner, F. O.
___ 2084 Giarratana, J.
___ 2095 Hunt, R. W.
___ 2101 Jayachandran, T.
___ 2112 Jennings, W.
___ 2123 Kildall, G. A.
___ 2134 Kodres, U. R.
___ 2145 Kolitz, B. L.
___ 2156 Little, W. A.
___ 2167 Litzler, L. G.
___ 2178 Lucas, K. R.
___ 2189 Marks, H. B.
___ 2190 Morris, G. W.
___ 2206 Pierce, J. P.
___ 2217 Preisendorfer, R. W.
___ 2228 Pulliam, F. M.
___ 2239 Roberts, A. B.
___ 2240 Schwarzkopf, A. B.
___ 2251 Shorb, A. M.
___ 2262 Singer, E. A.
___ 2273 Spalding, J. H.
___ 2284 Stewart, E. J.
___ 2295 Tranan, D. H.
___ 2301 Weir, M. D.
___ 2312 Wilde, C. O.

Department of Mechanical Engineering

___ 2323 Brock, J. E.
___ 2334 Cantin, G.
___ 2345 Houlihan, T. T.
___ 2356 Kelleher, M. O.
___ 2367 Lynch, E. F.
___ 2378 Marto, P. J.
___ 2389 Newton, R. E.
___ 2390 Nguyen, O. H.
___ 24D6 Prowell, R. W.
___ 2417 Pucci, P. F.
___ 2428 Tyvand, N. P.
___ 2439 Windrey, R. C.

Department of Meteorology

___ 2440 Alberty, R. L.
___ 3476 Carrigan, R. C.
___ 2451 Duthie, W. D.
___ 2462 Elsberry, R. L.
___ 3487 Hamilton, H. O.
___ 2473 Mahlman, J. O.
___ 2484 Martin, F. L.
___ 3498 Oakes, W.
___ 2495 Renard, R. J.
___ 2501 Taylor, C. L.
___ 2512 van der Bijl, W.
___ 2523 Williams, R. T.

Department of Oceanography

___ 2534 Andrews, R. S.
___ 2545 Boston, N. E. J.
___ 2556 Crew, H.
___ 2567 Oenner, W. W.
___ 2578 Geary, J. E.
___ 2589 Giles, C. F.
___ 2590 Haderlie, E. C.
___ 2606 Jung, G. H.
___ 2617 Smith, R. J.
___ 2628 Thompson, W. C.
___ 2639 Thornton, E. B.
___ 2640 Tucker, S. P.
___ 2651 van Schwind, J. J.
___ 2662 Wickham, J. B.

Department of Operations Analysis

___ 2673 Andrus, A. F.
___ 2684 Arima, J.
___ 2695 Barr, O. R.
___ 2701 Barrett, E. B.
___ 2712 Burnett, T. O.
___ 2723 Burton, R. M.
___ 2734 Butterworth, R. W.
___ 2745 Connolly, J. P.
___ 2756 Cunningham, W. P.
___ 2767 Ferguson, R. L.
___ 2778 Floyd, J.
___ 2789 Forrest, R. N.
___ 2790 Gieseke, W. J.
___ 2806 Greenberg, H.
___ 2817 Heidorn, G. E.
___ 2828 Higgins, J. E.
___ 2839 Howard, G. T.
___ 2840 Jones, C. R.
___ 2851 Kochems, R.
___ 2862 Larson, H. J.
___ 2873 Lindsay, G. F.
___ 2884 Marshall, K. T.
___ 2895 McMasters, A. W.
___ 2901 Milch, P. R.
___ 2912 Peterson, C. A.
___ 2923 Poock, G. K.
___ 2934 Preston, F. L.
___ 2945 Schrady, O. A.
___ 2956 Schwartz, H. J.
___ 2967 Shubert, B. O.
___ 2978 Shudde, R. H.
___ 2989 Taylor, J. G.
___ 2990 Tuck, G. A.
___ 3009 Tysver, J. B.
___ 3010 Woods, W. M.
___ 3021 Zweig, H.

Department of Physics

___ 3032 Armstead, R. L.
___ 3043 Buskirk, F. R.
___ 3054 Ceglio, N. M.
___ 3065 Cooper, A. W. M.
___ 3076 Cooper, J. N.
___ 3087 Coppens, A. B.
___ 3098 Crittenden, E. C., Jr.
___ 31D4 Dahl, H. A.
___ 3115 Oyer, J. N.
___ 3126 Eller, A. I.
___ 3137 Garrettson, G. A.
___ 3148 Handler, H. E.
___ 3159 Harrison, D. E., Jr.
___ 3160 Kalmbach, S. H.
___ 3171 Kelly, R. L.
___ 3182 Kinsler, L. E.
___ 3193 Lipes, R. G.
___ 3209 Medwin, H.
___ 3210 Milne, E. A.
___ 3221 Olsen, L. O.
___ 3232 Reese, W.
___ 3243 Riggin, J. O.
___ 3254 Rodeback, G. W.
___ 3265 Sanders, J. V.
___ 3276 Schacher, G. E.
___ 3287 Schwirzke, F. R.
___ 3298 Williamson, T. J.
___ 3304 Wilson, O. B., Jr.
___ 3315 Zeleny, W. B.

Navy Management Systems Center

___ 3326 Blandin, S. W.
___ 3337 Cantrell, G. K.
___ 3348 Childs, F. E.
___ 3359 Clark, R. G.
___ 3360 Dawson, J. E.
___ 3371 Doran, E. J.
___ 3382 Freed, E. J.
___ 3393 Kearns, W. A.
___ 3409 Martin, A. J.
___ 3410 Mauer, W. A.
___ 3421 Netro, R. J.
___ 3432 Plotkin, N.
___ 3443 Ulrey, I. W.
___ 3454 von Pagenhardt, R.
___ 3465 Wood, C. L.

Part III - Supporting remarks for your primary nomination (optional)

APPENDIX B

COEFFICIENT OF CONCORDANCE DATA FOR 01's AND 04's

	1	2	3	4	5	6	7	8	9
01	19	30.5	20.5	52	16	8.5	52	30.5	6.5
04	56	10	25	27	13	19	56	30	11

	10	11	12	13	14	15	16	17	18
01	14	52	20.5	52	5	52	36	4	18
04	12	34	36	46	14	39	20	7	26

	19	20	21	22	23	24	25	26	27
01	52	12	52	41	24	40	6.5	52	10
04	35	5	38	56	41	56	16	49	9

	28	29	30	31	32	33	34	35	36
01	52	34	11	8.5	22	23	52	52	39
04	56	6	17	2	18	15	43	44	56

	37	38	39	40	41	42	43	44	45
01	33	14	52	28	25	17	52	3	36
04	48	8	42	23	22	31	56	3	32

	46	47	48	49	50	51	52	53	54
01	1	52	36	14	52	52	52	52	52
04	1	56	37	33	56	56	56	24	56

	55	56	57	58	59	60	61	62
01	30.5	2	52	26.5	26.5	38	30.5	52
04	45	4	47	28	21	40	29	56

APPENDIX C

COEFFICIENT OF CONCORDANCE DATA FOR 03's, 04's, AND 05's

	1	2	3	4	5	6	7	8	9
03	3	80.5	15	19	80.5	45	26	11.5	41.5
04	2	74	47.5	9	19	32	36	17	27
05	2	34.5	5	12	30.5	53	37.5	1	52

	10	11	12	13	14	15	16	17	18
03	14	80.5	80.5	37	80.5	55	41.5	10	54
04	10	85	85	40	85	85	59.5	15	61
05	17	76.5	76.5	39	76.5	76.5	60	24.5	47

	19	20	21	22	23	24	25	26	27
03	80.5	9	11.5	7	51	52	13	46	80.5
04	59.5	16	14	24	55	43.5	51	53	56
05	54	13	19	37.5	76.5	27.5	10.5	76.5	55.5

	28	29	30	31	32	33	34	35	36
03	56	31	41.5	8	80.5	20	16	80.5	36
04	54	47.5	63	6	65	12	26	72	42
05	42	55.5	44.5	9	59	23	14	48	76.5

	37	38	39	40	41	42	43	44	45
03	80.5	27	64	59	69	48	80.5	80.5	80.5
04	85	20	80	85	73	31	70	85	79
05	76.5	30.5	50	76.5	40.5	44.5	76.5	76.5	76.5

	46	47	48	49	50	51	52	53	54
03	33.5	80.5	21	57	22	35	53	80.5	60
04	13	85	7	23	18	75	67.5	85	64
05	8	76.5	20	26	10.5	76.5	34.5	76.5	76.5

	55	56	57	58	59	60	61	62	63
03	58	65	67	62	47	30	68	80.5	24
04	78	57	71	35	29	49	43.5	62	39
05	57	76.5	61	76.5	50	29	76.5	76.5	18

	64	65	66	67	68	69	70	71	72
03	66	80.5	1	41.5	4	80.5	80.5	23	44
04	67.5	66	1	37	3	50	85	34	46
05	76.5	34.5	34.5	76.5	3	27.5	76.5	44.5	76.5

	73	74	75	76	77	78	79	80	81
03	2	80.5	80.5	63	5	6	49.5	25	18
04	4	30	85	76	5	25	52	22	11
05	15.5	21	76.5	44.5	5	24.5	76.5	22	5

	82	83	84	85	86	87	88	89	90
03	80.5	17	49.5	28.5	32	28.5	61	38	39
04	77	8	45	38	28	41	69	21	58
05	76.5	15.5	76.5	58	40.5	32	76.5	7	50

	91
03	33.5
04	33
05	76.5

APPENDIX D

COEFFICIENT OF CONCORDANCE DATA FOR FACULTY AND STUDENTS

	1	2	3	4	5	6	7	8	9
Faculty	18.5	136	136	136	136	136	36.5	33.5	33.5
Students	28	56	176.5	106.5	109	25	143	40	103.5

	10	11	12	13	14	15	16	17	18
Faculty	64	136	45.5	67	64	1	136	54	136
Students	79	176.5	6	99	46	4	53	50	135

	19	20	21	22	23	24	25	26	27
Faculty	136	2.5	59	67	136	136	136	59	64
Students	108	33	61.5	23.5	176.5	176.5	73	66	147

	28	29	30	31	32	33	34	35	36
Faculty	136	29.5	59	136	136	136	136	136	70
Students	27	141	150	139	20	176.5	87	130	83

	37	38	39	40	41	42	43	44	45
Faculty	136	54	136	136	56	50.5	136	17	76
Students	176.5	71	158	115	84	117.5	47	31	55

	46	47	48	49	50	51	52	53	54
Faculty	136	136	40	80	136	136	136	81	10
Students	34	176.5	8	68	138	176.5	57	88	48

	55	56	57	58	59	60	61	62	63
Faculty	136	136	136	136	136	136	31.5	136	136
Students	127	176.5	58	18	92	116	100	75	129

	64	65	66	67	68	69	70	71	72
Faculty	47.5	136	136	136	136	136	136	136	136
Students	19	21	39	152	77	91	26	176.5	136

	73	74	75	76	77	78	79	80	81
Faculty	11	136	136	136	14.5	136	136	136	136
Students	45	176.5	161	154.5	176.5	144	142	121	125

	82	83	84	85	86	87	88	89	90
Faculty	67	12	136	14.5	136	69	28	5	31.5
Students	159	29	162	37	176.5	50	59	12	42

	91	92	93	94	95	96	97	98	99
Faculty	136	14.5	136	136	52	78	77	136	7
Students	41	102	114	140	117.5	134	30	131	2

	100	101	102	103	104	105	106	107	108
Faculty	136	136	24.5	21	36.5	136	136	72.5	7
Students	153	60	52	76	90	82	176.5	15	16

	109	110	111	112	113	114	115	116	117
Faculty	136	24.5	136	36.5	136	136	36.5	2.5	136
Students	105	43	106.5	9	110.5	146	5	13	156

	118	119	120	121	122	123	124	125	126
Faculty	136	39	136	22	136	136	18.5	136	136
Students	176.5	22	154.5	44	81	157	23.5	61.5	113

	127	128	129	130	131	132	133	134	135
Faculty	136	136	136	9	136	136	41	136	136
Students	112	176.5	125	1	119	70	10	97	176.5

	136	137	138	139	140	141	142	143	144
Faculty	136	79	136	136	20	136	136	47.5	54
Students	93	120	50	176.5	86	176.5	176.5	133	176.5

	145	146	147	148	149	150	151	152	153
Faculty	136	136	136	136	136	45.5	24.5	29.5	136
Students	176.5	149	36	122	176.5	7	11	137	125

	154	155	156	157	158	159	160	161	162
Faculty	24.5	59	136	136	136	7	62	50.5	136
Students	103.5	32	14	160	89	64.5	67	110.5	54

	163	164	165	166	167	168	169	170	171
Faculty	136	43.5	49	43.5	136	4	136	136	82.5
Students	94	35	151	74	95	3	176.5	69	17

	172	173	174	175	176	177	178	179	180
Faculty	74	136	136	72.5	136	82.5	136	27	59
Students	128	101	98	145	72	78	132	38	64.5

	181	182	183	184	185	186	187	188	189
Faculty	14.5	136	136	75	136	71	42	136	136
Students	96	123	85	80	176.5	176.5	63	176.5	176.5

	190	191	192	193
Faculty	136	136	136	136
Students	176.5	148	176.5	176.5

APPENDIX E

COEFFICIENT OF CONCORDANCE DATA FOR FACULTY AND ALUMNI

	1	2	3	4	5	6	7	8	9
Faculty	1	59	88.5	54	26	59	21.5	19.5	4
Alumnus	10	83	21	18.5	18.5	41.5	83	43.5	41.5

	10	11	12	13	14	15	16	17	18
Faculty	51	46	3	18	78.5	33	69	105	62
Alumnus	83	83	1	43.5	83	39	83	83	83

	19	20	21	22	23	24	25	26	27
Faculty	105	32	105	34.5	105	30	43	73	16.5
Alumnus	83	83	83	35.5	83	83	37	32.5	83

	28	29	30	31	32	33	34	35	36
Faculty	19.5	46	52	105	29	41.5	59	82	105
Alumnus	9	49	83	83	23	52	83	83	53

	37	38	39	40	41	42	43	44	45
Faculty	7	93	31	90.5	105	40	53	49	11
Alumnus	5	83	83	83	83	17	83	83	29.5

	46	47	48	49	50	51	52	53	54
Faculty	46	105	59	59	105	39	6	25	27
Alumnus	83	83	83	83	83	6	83	83	83

	55	56	57	58	59	60	61	62	63
Faculty	41.5	105	105	85	12	38	76	75	90.5
Alumnus	7.5	83	83	83	45	15	83	83	34

	64	65	66	67	68	69	70	71	72
Faculty	105	80	85	46	10	105	23	46	82
Alumnus	50	83	83	83	83	12.5	21	83	83

	73	74	75	76	77	78	79	80	81
Faculty	14	56	78.5	5	34.5	77	74	8	50
Alumnus	21	83	83	11	83	83	83	4	83

	82	83	84	85	86	87	88	89	90
Faculty	13	105	87	28	105	92	15	82	36.5
Alumnus	24	51	83	29.5	35.5	83	28	12.5	16

	91	92	93	94	95	96	97	98	99
Faculty	66	36.5	16.5	9	64.5	105	105	105	85
Alumnus	83	39	83	3	83	32.5	83	26.5	31

	100	101	102	103	104	105	106	107	108
Faculty	24	105	2	71.5	71.5	63	67	68	94
Alumnus	26.5	83	2	54.5	48	83	47	54.5	83

	109	110	111	112	113	114	115
Faculty	88.5	105	70	64.5	21.5	105	55
Alumnus	14	39	7.5	83	83	46	25

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ABSTRACT

A study and documentation of the first annual Award for xcellence in Teaching is made. A brief background for the Award s presented, including the formation of a committee designated o choose objectively a worthy recipient. The problems encountered y the committee in designing a successful ballot and the statis- ical methods used in selecting the recipient are of major concern nd are treated in detail. Basic response statistics are published ccompanied by a data summary. Special studies including score nalysis, weight component determination, and teacher elimination y dominance techniques are presented. To better understand the arious population strata, several correlation studies are made.

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